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ABSTRACT

Intended for use by local school districts, this guide provides assistance to curriculum planners, members of boards of education, administrators, supervisors, classroom teachers, and others involved in and concerned about the development of science curriculum for elementary and secondary education. It is designed to assist in: (1) establishing goals and objectives; (2) developing procedures related to, for example, the selection of content, evaluation, special needs of students, and staff development; and (3) improving and maintaining ongoing science programs. Eleven steps for developing local science curriculum guides are outlined in section one. Major topics discussed in other sections include: philosophy, goals and objectives; K-12 science programs; content, skills, and attitudes; science for students with special needs; facilities; safety; instructional materials; science programs and the community; evaluation; and staff development. Examples are given to clarify discussion. Eighteen appendices provide further information such as statewide goals for education, legislation, lists of science curriculum guides, field tripsites and other information for Connecticut personnel. (DC)

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A GUIDE TO CURRICULUM DEVELOPMENT IN
SCIENCE

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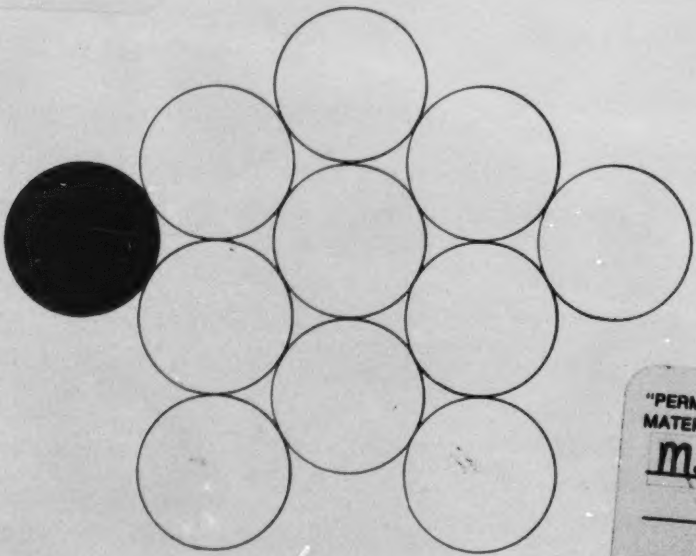

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This is one of a series of 12 guides to curriculum development prepared under the direction of the Bureau of Curriculum and Staff Development, Division of Elementary and Secondary Education, and published by the Connecticut State Department of Education. The guides may be reproduced in whole or in part as needed.

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Foreword

Connecticut has a strong commitment to equity and excellence in public education. The *Comprehensive Plan for Elementary and Secondary Education, 1980–1985*, embodies that commitment. Now this guide to curriculum development, part of a series, is one of the ways in which the State Board of Education is carrying out that commitment.

This concern for equal educational opportunity, dominant in the 1970s and continuing into the 1980s, has been expressed in a number of notable actions:

> The State Supreme Court's historic school finance reform decision *(Horton v. Meskill,* 1978) led to Connecticut's educational equity legislation.
>
> Statutes growing out of this concern for educational equity are Sections 10-262c, 10-262e and 10-16b of the Connecticut General Statutes. Sections 10-262c and 10-262e alter public school funding practices, more than doubling state support over a five-year period and setting a required minimum expenditure per pupil in each school district. Section 10-16b specifies educational programs which must be offered in all districts, with the requirement that they be "planned, ongoing and systematic."
>
> In Connecticut's *Comprehensive Plan for Elementary and Secondary Education, 1980–1985*, submitted to the General Assembly in 1980, the State Board of Education pledged to offer local school districts a greater level of technical assistance and more positive leadership in planning, implementing and evaluating school programs.

The guides have been developed to provide tangible assistance and support to local school districts in complying with the legislative mandate. The titles of the guides correspond to the subjects which Section 10-16b requires all school districts to offer their students: the arts; career education; consumer education; health and safety; language arts, including reading, writing, grammar, speaking and spelling; mathematics; physical education; science; social studies, including, but not limited to, citizenship, economics, geography, government and history; and, at least on the secondary level, one or more foreign languages, and vocational education. The goals and objectives set forth in each of the guides relate to the statewide goals endorsed in the *Comprehensive Plan*, namely, motivation to learn, mastery of the basic skills, acquisition of knowledge, competence in life skills and understanding of society's values.

Science and technology play an increasingly important part in everyone's daily life. They influence the products we buy, the ways in which we communicate, the sources of energy we use, our means of transportation, our health care and our environment, even the public policy issues on which we are asked to vote. Connecticut citizens, in every aspect of their economic, social and cultural activities, are called on to make decisions and take actions that require an understanding of science and its applications.

The schools play a key role in bringing to these citizens—especially to the young—the knowledge and skills of science that they need and will need in the future. The schools, as they have done in the past, should continue to present scientific knowledge as open-ended, always subject to challenge and change.

Just as knowledge and skills change, so must the content and methodology of science programs. *A Guide to Curriculum Development in Science* has been written to assist curriculum planners to examine their present science programs and to update and revise them when change and improvement are necessary.

The State Board of Education curriculum guides are not mandated courses of study for any student or any grade level. Each guide is intended solely to assist local district educators in the development of curricula. Each guide reflects the thinking and experience of an array of experts in its subject area who become, through this document, an important resource to local district educators.

The Connecticut State Board of Education frequently has expressed its conviction that the diversity of the state's public school system is one of its great strengths. Students, schools and communities do not have identical educational needs; imposing a standardized curriculum would impair, not improve, learning opportunities for students.

It is important for local district educators to keep the position of the Board in mind as they use this guide. There is much of value here which can be used to strengthen instructional practices and promote excellence in the curriculum development process. But these ideas can only enhance, not replace, the creativity, talent and commitment of the people in our local school districts who use this guide.

Mark R. Shedd

Mark R. Shedd
Commissioner of Education

Acknowledgments

A Guide to Curriculum Development in Science is the result of the work of many individuals. Their assistance in the host of tasks required to develop the document has been invaluable and is much appreciated.

The Science Curriculum Advisory Committee provided direction to the major thrusts of the guide. It also gave valuable constructive criticism to the several drafts which were developed during the course of the project. The committee consisted of the following members:

Ray Delehant, Orchard Hill Junior High School, North Haven
Bette DelGiorno, Fairfield Public Schools
Alan Haught, United Technologies Research Center
Madeline Goodstein, Central Connecticut State College
Sarah Klein, Roton Middle School, Norwalk
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Elbert Terry, Hartford Public Schools
Wilma Toney, Weaver High School, Hartford
Charles Vazquez, Darien High School
Ralph Yulo, Eastern Connecticut State College

Four members of the committee—Donald LaSalle, Robert Shackleton, Marten Tafel, and Ralph Yulo—and Millicent Tissair, Roger Ludlowe High School, Fairfield, wrote major portions of the guide. Their patience and willingness to work far beyond the call of duty is gratefully acknowledged.

A special thanks is extended to the Connecticut Science Teachers Association for allowing the use of its "Suggested Science Competencies" document which was developed under the leadership of Bette DelGiorno.

The work of Frank Salamon in rewriting portions of the guide and in acting as editorial consultant is sincerely appreciated.

Finally, to lend a national perspective to the document, a developed draft was reviewed by two science educators from different parts of the country. To Dr. Francis P. Collea, California State University and Dr. Leonard M. Krause, Philadelphia School District, the thanks of the Department for their efforts toward the improvement of *A Guide to Curriculum Development in Science*.

Sigmund Abeles
Consultant in Science Education

Developing a Science Guide 1

Curriculum guides rarely if ever find their way to the top of best-seller lists. Quite the contrary—guides more commonly have been found gathering dust on library shelves or settling slowly to the bottom of rusty file cabinets to shore up crumbling dittos of last year's science tests.

It is hoped that this document, and guides developed from it, will be different. This guide to curriculum development addresses a number of questions that school district administrators, supervisory personnel and teachers often ask about programs in science, such as:

- What is an appropriate scope and sequence of science offerings?
- What are the important concepts to be taught?
- With the current emphasis on accountability, on goal statements, and student objectives, how can they be worked into the science program?
- How are textbooks and other instructional materials selected?
- What are important safety considerations for classrooms and laboratories?
- What scheduling and staffing patterns, time for laboratory activities and approaches to science instruction should be considered in developing and operating a science program?
- How is use made of community resources, professional organizations and other sources of support for science programs?

The purpose of this guide is to suggest answers to these and related questions so that when educators from a local school district sit down to plan their own science program, they will have guidelines and information with which to work. Beyond this, it is hoped that this guide will provide assistance with recurring questions involving science programming and science classroom management. If these purposes are served, then the creation of this document will have been justified.

Intent of the guide

This guide is intended primarily for curriculum planners, many of whom may be teachers. But the guide is also designed for a broader audience. Among those for whom the guide is intended are:

- **Members of local boards of education.** The local board of education is responsible for approving the science curriculum as a part of its program of studies and for assuring that it is consistent with the best educational practices that can be brought to bear. The local board is also responsible for assuring adherence to state and federal guidelines. This guide provides an overview of what is involved in developing a quality science curriculum for K–12.

- **Administrators and supervisors.** The administrators and supervisors in the local school district are responsible for providing overall guidance and supervision for curriculum development as well as assurance that the goals and objectives in the district are met. School administrators and supervisors are responsible for scheduling time, providing needed resources and assuring a proper sequence for the science program. They must be familiar with the many components of the program and the means by which they were developed.

- **Classroom teachers.** Ultimately, and consistently, the responsibility for working with students, and providing them with the content, skills and values inherent in the study of science falls to the classroom teacher. Curriculum guides can help provide an overall K–12 content within which a teacher can view a specific course and present the conceptual framework for that course in relation to the offerings which precede and follow it.

While diversity of content selection and methods of presentation are cornerstones of educational programs in a democratic system, there are certain objectives which should be targeted in each science program. A curriculum guide can be useful to teachers by indicating what these objectives are and providing suggestions for their achievement.

References to examples of state and local guides appear in Appendix C.

Uses of the guide

This guide can be used in three ways: 1) to assist in establishing goals and objectives for the science program; 2) to assist in developing procedures in such areas as the selection of content, evaluation of materials and facilities, methods for dealing with students with special needs, and staff development for science teachers, and 3) for an ongoing science program, to suggest procedures for selecting new texts, methods of maintaining a safe environment in the laboratory, resources for acquiring student evaluation instruments, ideas for new courses, and types of staff development activities for teachers.

Development of a local science guide

To be most productive, a procedure for development of a local science curriculum will make use of a coordinated effort among community representatives, administrators and supervisors, and the practitioners—the teachers—to as great an extent as possible. A science program which has no investment from those who will use it offers little guarantee of success. The following 11 steps are suggested for the development of a local science curriculum guide.

Step 1—Organize a science curriculum development committee. Select representatives from various levels—elementary, middle/junior and senior high schools. Administrators should also be represented; this will keep them informed of the committee's questions regarding district policies and procedures which can influence the development of the program. Identify resource personnel from other appropriate subject matter areas, from the community—particularly in science-related enterprises, and from higher education. These people can be called upon to give advice and assistance as the project progresses.

Step 2—Assess the status of the present local science curriculum. Before moving into a new program in science, the present program should be studied. What are its weaknesses and its strengths? What materials are on hand? How do teachers feel about what they are doing? What problems are there? What is needed in the new program that can help address those problems? Much of this information can be provided by individual teachers; much can be provided by the science curriculum development committee.

Step 3—Research other science programs. Contact other districts, the State Department of Education, and commercial vendors to determine what recent program developments have taken place and what new materials are available. Often a science program, or elements of it, have been adopted by a nearby district which may be willing to share its experiences. Staff of the State Department of Education can suggest school districts that are able and willing to provide this kind of assistance. In addition, department staff are knowledgeable about many recent practices both on a state and national level.

Step 4—Develop a philosophy and goals for the science program. A program in science should have a basic philosophy as its foundation. There should be goals for the program which are consistent with that philosophy. Program and student objectives follow from the philosophy and goals. This approach will let everyone know what you're trying to do, why you're trying to do it and what is expected of those who take part in it. Once the science curriculum committee has prepared its own philosophy and goals, let other teachers, administrators, selected parents, students, board members and other citizens outside the school system look at them and give their thoughts. This information should be reviewed by the science curriculum committee and used for possible revision. The development of philosophy, goals and program objectives is discussed in Chapter 2.

Step 5—Prepare a scope and sequence for the program. Science programs run from K–12 and they should be designed along those lines. Even if a specific component of the program, e.g., K–6, 7 and 8, is of interest at a particular time, there should be an overall scope and sequence available so that such revisions do not lead to duplication or omission. Suggestions for scope and sequence appear in Chapter 4.

Step 6—Prepare the specific objectives for the science program. The objectives for each course at the high school level can be developed by the teacher of that course. The elementary school teachers might usefully break into groups for the primary (K–3) and intermediate (4–6) grades to deal with the science objectives at those levels. Objectives should be stated clearly and concisely. Examples of these appear in Chapter 4.

Step 7—Obtain reactions to the goals and objectives. The final step in putting together the scope and sequence with its goals and objectives should be to get reactions. The reactions should come from science teachers, from representatives of other subject matter areas such as mathematics, reading, social studies, from the administration and from interested community people. Special care should be taken to assure that the science program is consistent with the mathematics program so that students have the necessary mathematical skills. While it is often true that science teachers must teach some mathematical skills in a science context, efforts should be made to ascertain that the necessary mathematical operation or skill has been presented at a time appropriate for the teaching of the science concept.

Step 8—Assure the provision of resources for the program. The scope and sequence and the objectives for the program provide the structure for the acquisition of materials. Major attention should be given to facilities (see Chapter 6) and to assuring a safe and comfortable environment for students (see Chapter 7). Instructional materials, such as textbooks and media materials (see Chapter 8), should be selected to be consistent with the philosophy, goals and objectives of the program. Staff development (see Chapter 11) is an important element in maintaining an active and vital science program.

Step 9—Prepare a plan for implementing the program. When the preceding steps have been completed, a plan for putting the program into operation should be developed. When will materials arrive for distribution? What about acquisition of living things which must be on hand at a particular time? What about resupply? When is the appropriate time for a particular staff development activity? What about evaluation? What about new teachers? Consideration should be given to these and to other similar questions necessary to implement the program.

Step 10—Evaluation of the new program. There are two major types of evaluation for the new program. The first involves the extent to which the students are able to meet the objectives of the program. Are they appropriate? Are they at the right level? Should they be changed? This first type of evaluation is an important component of the second—that is—how effective is the program? Is it advancing achievement? Are students obtaining the knowledge and developing the expected skills? Suggestions for testing and evaluation for use with local science guides appear in Chapter 10.

Step 11—Continually revise the program. Content and skills are not static—certainly not in science. Daily changes in technology, new discoveries in knowledge and new instructional approaches make the science program a continually varying entity. It must always be studied so that changes may be introduced as necessary.

It can very easily be true that once the first blush of the new local curriculum fades, little may be done to revise it. Curriculum revision needs to be continual and every consideration should be given to keeping the curriculum abreast of what is taking place in society.

The format for the science curriculum guide should make the presentation of the material as clear and as useful as possible. While there is no single fixed format, the three-column or four-column presentations are probably the most common. (For examples, see Appendices D and E.)

Following the above steps can assist a local school district in the development of its own science curriculum guide but only if this volume and the guides it generates are not allowed to gather dust or shore up old science tests.

Philosophy, Goals and Objectives

2

Our increasing knowledge of the rapidly changing world in which we live, brought about in large measure through our efforts in science and technology, makes it essential for all citizens to be literate in these fields. While not everyone is or should be a physicist, biologist, chemist or engineer, everyone needs to know something about the nature of science, how it works, what it can and cannot do.

Because there is so much misunderstanding about science, it is particularly important to help students understand the nature and value of scientific theories. Scientific theories are general statements that explain and organize a large number of facts, generalizations, or events. All scientific theories are tentative because science itself is a dynamic enterprise. No scientific theory can be proven in any absolute or final way, but each theory can be used with more and more confidence every time new observations or experiments produce results that are consistent with predictions based on the theory. Some students may think that theoretical ideas are not very practical; just the opposite is true. There is nothing more practical than a fruitful theory because it enables scientists to predict, explain, and give structure to so many previously unrelated facts. Indeed, the formulation of valid general statements—scientific theories—which in succinct form reveal the relationships between objects and events, can be said to be the most important and fundamental goal of science.

Structuring a philosophy

Schools play a vital role in providing information and in developing attitudes toward science and technology. They also help future citizens learn how to make responsible choices regarding science and society. As such, the science program must be an essential part of the total school program.

It is important that everyone in the school district—citizens, board members, administrators, teachers and students—knows the rationale for the science program: why the program exists, what it is trying to accomplish and how it will go about doing it. For example, will the program concentrate on the teaching of concepts, skills, facts, processes or some combination of these? Will the program be textbook oriented to the exclusion of laboratory experience? Will it be directed at the individual or at groups? Will it be inquiry oriented?

The philosophy should include:

- reasons for offering the program;
- general statements as to what the program will do, and
- general statements as to how the program will accomplish what it intends to do.

Examples of philosophies

The philosophies which follow have been extracted from selected curriculum guides in science or from the statements of professional science associations. Note that each philosophy addresses the three criteria mentioned above. These examples can serve as models or as points of departure in composing a philosophy for the local curriculum guide in science.

The following example is drawn from a statement prepared by the American Association for the Advancement of Science.

> The first task and central purpose of science education is to awaken in the child, whether or not [he/she] will become a professional scientist, a sense of joy, the excitement, and the intellectual power of science. Education in science, like education in letters and the arts, will enlarge the child's appreciation of [her/his] world; it will also lead [him/her] to a better understanding of the range and limits of man's control over nature.
>
> Science is best taught as a procedure of inquiry. Just as reading is a fundamental instrument for exploring whatever may be written, so science is a fundamental instrument for exploring whatever may be tested by observation and experiment.
>
> Science is more than a body of facts, a collection of principles, and a set of machines for measurement; it is a structured and directed way of asking and answering questions.

The Iowa Department of Public Instruction has developed a philosophy of science education which includes the following statements:

> Science education is the link between science and society. Its ultimate goal is to DEVELOP SCIENTIFICALLY LITERATE CITIZENS who use and understand the impact, knowledge and processes of science.
>
> The study of science offers a KNOWLEDGE OF NATURAL PHENOMENA that uniquely rests upon the notion that humans can test and understand the orderly nature of the universe. Fundamental to this proposition is a need for students to develop and apply the logical thought PROCESSES OF SCIENCE AS PART OF THEIR BASIC LEARNING. These processes are best developed through a well-articulated science program that includes experimentation and manipulation of materials.

Yet another statement of philosophy, created by the Indiana Department of Public Instruction, contains these passages:

> Science and technology affect nearly every aspect of our lives; thus, all participating citizens of a democracy need to be scientifically literate. All high school graduates need basic science competencies. A wise decision-making, problem-solving, scientifically literate citizenry is the expected end product of the science program . . . .
>
> Science is not just a body of facts, theories, and laws, but it is also a unique way of knowing—a way to generate knowledge.
>
> The value of science education lies in its problem-solving inquiry methods . . . .
>
> Students must apply scientific knowledge, as well as knowledge from other disciplines, as they attempt to solve problems which are meaningful to them. Decision-making teaching strategies give purpose, meaning, and motivation to learning . . . .

Finally, this last example was written by a parent, a scientist, and a member of the Connecticut Science Curriculum Advisory Committee.

> With the increasing role of technology in all elements of our society, it is important for everyone to have an understanding of the nature of science, how it works, and what it can and cannot do. The fundamental principles and methods of science form both a knowledge base for understanding and a framework for learning. In the science program, principles and methods of science will be developed through both textbooks and laboratory experiences by involving each student in the major areas of earth and space science, biological science, and physical science at increasing levels of sophistication through the grades.

The philosophy for the science program should set its direction and tone. The goals and objectives for the science program rest on this philosophy. They should be consistent with it while lending greater definition to what the program will provide.

Goals for a science program

Goals are intermediate in specificity between the philosophy and the statements of objectives which are used to detail student outcomes.

There has been and continues to be considerable controversy over the usefulness for instructional purposes of student objectives. Many teachers are sufficiently knowledgeable and are organized well enough to know with great detail what they intend to teach and what they expect their students to know and perform without written objectives. The significant advantage of written statements of goals and student objectives is that they are visible. This allows them to be discussed, analyzed, evaluated and, if necessary, revised. It allows everyone involved to know what is being attempted and what types of performance are expected.

Statements of goals are developed based on the assumption that the reasons for the approach stated in the philosophy to the science program have been accepted. The science program is acknowledged as an important component of the district's educational offerings and the general instructional approach to it is considered appropriate.

The goals themselves are written to provide the framework for specific instructional objectives and activities. They indicate what the program is to accomplish. The following examples of goals for science teaching, extracted from various sources, can be useful in developing the local curriculum guide in science.

Examples of goals

The following examples of goals have been developed by professional associations or by state curriculum guide development committees. As was the case for the philosophies for science education, these goals can serve as models or as points of departure for the development of local goal statements.

The following four goals for a science program are taken from the *South Dakota Framework for Science Curriculum Development K–12* produced by the South Dakota Department of Education and Cultural Affairs.

The goals for science instruction are:

1. To develop those values, interest and attitudes which underlie the personal involvement of the individual with his/her environment and with mankind.
2. To develop the rational thinking processes which underlie scientific modes of inquiry.

3. To develop fundamental skills in the manipulation of materials and equipment; in the care and handling of living organisms; and in the collection, organization and communication of scientific information.
4. To develop knowledge of processes, facts, principles, generalizations and applications—the products of science—and to encourage their use in the interpretation of the natural environment.

As can be seen, these goals are more specific than are the philosophies. They seem to add direction to the science program and open the way for yet more specific statements of outcomes to be obtained.

The National Science Teacher Association in its documents *Theory into Action* and *School Science Education for the 70s* published these statements:

> Science teaching must result in scientifically literate citizens . . . . To promote scientific literacy, science curricula must contain a balanced consideration among conceptual schemes, science concepts, and science processes including rational thought processes, the social concepts of science and technology, and values deriving from science. Scientifically literate persons will use the achievements of science and technology for the benefit of mankind. These goals must be achievable, at least in part, during the immediate school experience.

From the Michigan Department of Education comes the following goal statement:

> Our goal of science education is to develop scientifically literate citizens with the necessary intellectual resources, values and attitudes and inquiry skills to promote the development of a man as a rational being.

The statements of goals are also referred to as "program objectives" or sometimes as "objectives." In general the distinguishing feature between statements of goals or program objectives and the student or performance objectives which appear in the next section is that goals are directed toward what the program should offer while student objectives are specific as to what the individual learner is to do.

Objectives for students

Objectives for students are often referred to as performance objectives. The identifying feature of this group of statements is that they define what the student is supposed to do.

If a goal for the program in science is to "develop scientifically literate citizens," then what is it that the students must do to achieve that goal? If a goal of the program in science is "to develop an understanding of the interrelationship between matter and energy," then how must the student demonstrate that understanding?

Ideally, student or performance objectives must be written to describe in specific terms the behavior to be exhibited by the learner. Often, excessive specificity can be frightening. For example, "The student, given a battery and battery holder, a bulb and one ten-inch length of conducting wire, will in five minutes and in two different configurations construct a circuit such that the bulb will light."

While this fright often may be more apparent than real, the level of specificity of student objectives can be less threatening and the means of stating and evaluating performance left in greater degree to the teacher if the objectives are presented in less specific language.

Some student objectives follow. These were selected as examples from a variety of disciplines for different levels of instruction.

Primary grades. The student will:

- list those things soil must have to make plants grow well;
- describe how soil helps animals;
- list and describe those things that should be added to the class aquarium to keep the aquarium balanced, and
- list at least three requirements for the growth of all green plants.

Middle school/junior high school. The student will:

- prepare a demonstration to show that sound cannot go from one place to another without the presence of matter;
- contrast the similarities and differences between fog and clouds, and
- demonstrate how to mount a slide on the stage of a microscope and how to focus the scope using different power objectives.

Secondary school. The student will:

- compare, contrast and discuss food chains and webs;
- explain the relationship of temperature to the kinetic molecular theory;
- relate the flow of fluids to pressure;
- identify the basic metric (SI) units that are used for measuring length, weight, volume and temperature, and
- define an ecosystem and compare biotic and abiotic components of the system.

These objectives, while more specific than the statements of goals described in the previous section, are still less specific than the battery and bulb example at the beginning of the section. If members of local curriculum committees so desire, they can introduce this specificity into the objectives in their science guides to meet the needs of their own school populations. The examples given above and in Chapter 4 were developed for broad populations of students. It is intended that they provide direction for the content of the local curriculum guide while still permitting the flexibility necessary for individual situations.

Science—Kindergarten Through 12th Grade 3

In recent years the science curriculum in the schools has been the focus of much controversy. Many innovative courses have been written for different levels of instruction. In these courses, the emphasis has been placed on the process of scientific inquiry and the development of concepts rather than the memorization of a body of facts. All science courses or programs should be laboratory-oriented. Such laboratory experiences can be undertaken either in the laboratory or in the field.

In general, the courses or programs in science fall into two broad categories:

- Courses or programs developed on a national level through the auspices and funding of the National Science Foundation or similar organizations. These programs generally featured authorship by teams at writing conferences. Activities were pretested on a large scale, and materials were designed for use by the students. Typical examples of these courses or programs are the "Science–A Process Approach" (SAPA), the "Elementary Science Study" (ESS), the "Biological Sciences Curriculum Study" (BSCS), and the "Intermediate Science Curriculum Study" (ISCS). After extensive development, pilot testing, and evaluation, the materials produced were placed in the hands of commercial publishers for production and distribution. Over the years, these programs, or parts of them, have appeared in commercial publications.

- Courses or programs developed by commercial publishers. This category includes standard science texts and other materials which are the mainstay of science programs. Taking their lead from the national curricula, some of these programs also feature a student-centered inquiry approach and materials designed for student use.

Recently, perhaps because of declining enrollments and budgetary constraints, perhaps because of the emphasis on the basic skills, or perhaps because of the perceived need for more structured program approaches, there has been a reduced emphasis on student activity in science. Unfortunately, and particularly at the elementary school level, this has resulted in a number of courses and programs overemphasizing reading and description at the expense of an activity-centered approach.

Importance of up-to-date programs

Experience of the past 20 years has shown that students need an education in science which not only keeps them abreast of recent developments in this field but which also allows them to cope with the everchanging requirements of a dynamic society. Modern science courses have real meaning only to the extent that they allow the students to function better in their present and future environment.

Modern science courses attempt to use materials which are appropriate to the child's developmental state and which include both process- and content-oriented materials. Because of the rapid changes in science and technology, it is *essential* that texts and instructional materials be recent and appropriate.

The elementary school program

Science should be a vital part of the elementary school curriculum for every child. Skills that should be taught in an elementary science program include observation, measurement, classification, prediction, communication, interpretation of data, experimenting, recognizing and controlling variables, and formulation of hypotheses.

All elementary science programs should address the three major content areas: biological science, physical science and earth science. Elementary school curricula may conveniently consist of separate short units that can be completed in one period of time.

According to the developmental psychology of Piaget, elementary school youngsters are at the stage in their growth when they can benefit most from experiences with concrete rather than abstract situations. Most students will learn ideas and concepts much more easily if they can begin with the concrete situations upon which generalizations may be developed. Therefore, units should include many hands-on discovery activities and, especially in the lower grades, be qualitative in nature. A laboratory approach can stimulate a child to learn science concepts in which the child initially may not have an interest.

In the primary grades, science is an excellent tool to help develop a child's vocabulary and reading interests. For example, when one is teaching a unit on properties, the words used to describe the object can be used as a vocabulary list which can be gradually expanded as the sophistication of the description increases. There are many excellent science books written for elementary school children which may attract their interest and which may help increase their desire to read.

Mathematics should be integrated with science whenever possible. Many opportunities to use mathematics occur in the areas of measuring, using numbers, experimenting, etc. For example, when one is measuring the growth of plants over a given time period, graphing should be introduced as a tool to record the results. Where appropriate, the mathematics and science lessons can be combined, thus allowing more time for science in an already crowded day.

Preparation of teachers through in-service training or a packaged unit with a teacher's guide is especially important at the elementary level where many teachers do not have a preparation in science. There are also many units available where no special equipment is needed and which both teacher and students can enjoy. The presence of a science specialist in the school is highly recommended to aid teachers in selection of appropriate units.

The middle/junior high school program

The middle and junior high schools have traditionally taken many different forms but usually include some combination of grades 5 through 9. While experience has shown that there is distinctive need for this age-grade grouping, the middle or junior high school is often thought of in terms of a "capstone for elementary or stepping stone to high school" (Hurd, 1960). To be truly effective the middle/junior high school program must be more than these; it must stand on its own merit, fulfilling the needs of early adolescent youngsters (10–15 years of age).

Middle school programs in science should not be the upper end of an elementary science program followed by an unrelated beginning of a secondary science program. Care should be taken to assure that there is a logical sequence of concepts and processes moving from the lower to the higher middle school grades.

Within the framework of the total school experience, science at this level should contribute primarily to the development of concepts. The processes of science, which include the development of necessary skills, both physical and intellectual, make it possible for the student to inquire into his/her environment. Valid relations among topics or concepts in science and other academic disciplines should be encouraged. The development of student self-awareness and an understanding of her/his place in our society should be part of the curriculum at this level.

The high school program

The organization of science into independent subjects such as earth science, biology, chemistry, and physics has been standard at the high school level. However, the content of science courses has undergone many changes. Originally this content was designed to prepare students for college. Presently, the content of science courses is designed for a broad spectrum of students ranging from those going to college to those entering the workforce.

The goal of a scientifically literate society is even more relevant today than it was in the past. Since everyone needs an understanding of science, today's high schools must undertake the fulfillment of a diversity of goals. One is the development of science skills and a knowledge of science for students not seriously interested in science as a career. Another is the opportunity for career development, both terminal and preparatory, in scientific and technical areas. Other goals are preparation for further academic pursuit or special activities for students or high interest or ability.

It should not be forgotten, however, that secondary schools provide for the general education of students, and that in science, at the minimum, these offerings should include earth science, biology, chemistry, and physics.

Suggested time allotments

The teaching of science is an essential component of the school program. Instructionally, there should be a heavy orientation toward student activity and laboratory experience. This type of instructional approach requires time and, as a result, there should be a local policy regarding time allocations for science instruction.

Based upon data from a National Science Foundation survey as well as from a survey of times allotted to secondary school science courses in Connecticut, the Science Advisory Committee recommends the following amount of time to be used for instruction in science.

Time Recommendations

Grades	Minutes Per Week
1–3	75 to 150
4–5	135 to 200
6–8	250 to 300
9–12	280

In grades 1–5, science instruction is often integrated with instruction in other subject disciplines such as mathematics and social studies.

In grades 6–8. science is most often taught as a separate subject. The time recommendation at this level is based upon a minimum of five 50-minute periods per week or their equivalent to allow for laboratory experience.

For the high school, seven periods per week or a time equivalent to 280 minutes per week is recommended. This figure is based upon seven 40-minute periods per week to provide for laboratory experiences. However, it may be met by other scheduling periods of different lengths.

Patterns of science offerings

There are a number of different science offerings in Connecticut. These offerings have been designed to address the interests and needs of the large body of students taking science in this state.

Typically, the elementary science program K–6, whether reading oriented or activity oriented, includes topics in the earth, biological, and physical sciences.

Starting in grade 7 two different patterns emerge. One, the "block" program, consists of one full year each of life science, earth science and physical science. This pattern is used in approximately 80 percent of the schools in the state. The other pattern is a "spiral" or general science program and appears in the other 20 percent of the schools. This program consists of a general science offering in grades 7 and 8 and sometimes in grade 9 as well.

At this level, provisions are made for students of high ability who can benefit from acceleration; for students who are preparing for college; for students who are working for a nontechnical high school diploma, but who may be interested in an occupation rather than a college program, and for those students who have a vocational or technical career in mind which will start after the acquisition of a high school diploma. It is recommended that all students be required to study science in each of the grades 7 through 9.

In the light of recent declines in physical science test scores on both the National Assessment of Educational Progress (NAEP) and Connecticut Assessment of Educational Progress (CAEP), it is further strongly recommended that all students take, in addition to biology, at least one and preferably two years of physical science in the 9–12 sequence.

Table 1 on page 17 gives examples of some programs. They can serve as model structures which can be used either as they appear or as points of departure for the development of a local program sequence.

Electives in the science program

Most programs in science go beyond the basic offerings of biology, physics, chemistry, and earth science. In fact there are more than 50 other elective courses in science. A number of these are mentioned in Appendix E. Some of the more popular programs appear in the following sections and in Chapter 9.

The advanced placement program. Most secondary-school curricula allow for electives. It appears that the advanced placement courses in chemistry, physics, and biology are among the more popular. These advanced courses go beyond the typical high school science course and are usually offered to the superior student interested in science. Students who take these advanced-placement courses may—on the basis of examination—be granted advanced placement or credit at the college level. The Advanced Placement Program is administered by the College Entrance Examination Board of the Educational Testing Service of Princeton, New Jersey, to which any questions regarding the examination or other aspects of the Advanced Placement Program should be directed.

College credit. High school students in Connecticut are able to earn college credit by enrolling in courses in area colleges. Several of the state's institutions of higher education allow high school students, upon the recommendation of the principal or counselor, to enroll in courses on a space available basis for no fee or for a nominal charge. Some of the colleges charge full tuition. Colleges within a reasonable geographic area should be checked to see what arrangements can be made to accommodate interested students.

The University of Connecticut Cooperative Program. Many students throughout the state are earning college credit for courses they are taking in their local high schools. Some of these college credits are earned under the auspices of the University of Connecticut Cooperative Program. Under the terms of this program, secondary school teachers who are approved by the University can offer courses for university credit in the sciences and other academic areas in their schools. The student who successfully completes these cooperative courses is granted advanced standing if he/she attends the University of Connecticut. Any questions regarding this program should be directed to the University of Connecticut Cooperative Program in Storrs.

Independent study and work study. Students who are interested in obtaining college credit for work they have done in independent and/or work-study arrangements should get information about the College Level Examination Program or CLEP. This is another program which was developed by Educational Testing Services of Princeton, New Jersey, and administered by institutions of higher education. Most school counselors have information about this program.

Other elective programs. Other elective programs have been built around the following:

- computer assisted instruction
- team teaching
- use of teaching assistants (who act as tutors because of some special skill or knowledge)
- use of community resources
- contract learning or individually prescribed instruction (IPI)
- summer schools for enrichment
- released-time programs
- community or other educational programs after school or on Saturdays
- work-study programs (the students spend half the day or other periods of time in career-oriented placements or apprenticeships)
- self-teaching courses, including correspondence courses which may or may not be paid for by the school

The electives and the methods of implementation of these electives in the science curriculum are limited only by the imagination of the person(s) planning the program.

Remedial programs

A number of students who have difficulty with science concepts or with mathematical skills can benefit from instruction which will reinforce the operations or understandings underlying them.

This instruction should be directed at the particular need of the student. The type of remediation will also depend upon the student. Sometimes the instruction is directed toward concrete operations; often there is a strong emphasis on the ability to read. In some instances instruction is directed toward bridging the gap

Table 1
Examples of Science Offerings
In Connecticut

<table>
<tr><td>Grade
K–6</td><td colspan="4">Life Science
Earth Science
Physical Science
Inquiry and Process Skills</td></tr>
<tr><td></td><td>Vocational Technical Career Orientation</td><td>Noncollege Bound Science Program</td><td>Precollege</td><td>Accelerated</td></tr>
<tr><td>Grade 7</td><td>Life Science, or General Science</td><td>Life, Physical, Earth Science or General Science I</td><td>Life, Physical, Earth Science or General Science I</td><td>Life, Physical, Earth Science or General Science I and II</td></tr>
<tr><td>8</td><td>Physical, Earth Science or General Science</td><td>Life, Physical, Earth Science or General Science II</td><td>Life, Physical, Earth Science or General Science II</td><td>Life, Physical, Earth Science or General Science II and III</td></tr>
<tr><td>9</td><td>Earth or General Science</td><td>Earth, Physical Science or General Science III</td><td>Earth, Physical Science or General Science III</td><td>Biology</td></tr>
<tr><td>10</td><td>Chemistry or Biology</td><td>Biology</td><td>Biology</td><td>Chemistry</td></tr>
<tr><td>11</td><td>Physics</td><td>Applied Sciences, Electives: Physical Science, Consumer Chem., Applied Health, Computer Science</td><td>Chemistry</td><td>Physics</td></tr>
<tr><td>12</td><td>Physics, Physical Science</td><td>Laboratory Tech., Animal Tech., Electronics, Electricity, Science and Society</td><td>Physics</td><td>Electives: Advanced Science or Advanced Placement Science</td></tr>
</table>

between mathematics and science. The object of the instruction is to get the student to be able to function adequately in the regular science program. Courses should not be "watered" down, but should provide attention to the particular needs of the student so that they may be satisfied. In this way an attempt is made to assure that students leaving the school will have the science background necessary to enable them to succeed either with further schooling or on the job.

4 Content, Skills and Attitudes

The basic science program should include the three major areas of earth and space science, life science, and physical science. The content in these three major areas may vary to some extent from one district to the next, or from one program to the next, but there are many areas of content, many skills and many attitudes which are common to most, if not all, elementary and secondary school programs in science. Very often, there are differences in approach to the teaching of science. One example of this difference is the emphasis on reading in some textbooks in elementary science as opposed to an emphasis on student activities in other textbook series. A checklist for selecting textbooks and textbook series is discussed in Chapter 8 and appears in Appendix G.

The following section on content, skills and attitudes can help in determining the substance of the program.

Objectives for science programs

The Connecticut Science Teachers Association (CSTA), over a four-year period, has identified the conceptual, skill and attitudinal objectives which it believes can serve as guideposts for local school districts developing a program in science. An overview of these objectives appears in Table 2, on page 26. A more extensive listing of the specific objectives, to be attained upon completion of grades 4, 8 and 12, follows. Specific objectives listed are arrived at gradually and may be partially achieved in earlier grades. Those objectives preceded by an asterisk were added to those developed by the Connecticut Science Teachers Association.

Science Objectives
For Students Completing Grade 4

Concept objectives in life science

Major Concept: Living things respire, need nourishment and water, and reproduce their own kind.

- List at least three requirements for the growth of all green plants.
- List functions that distinguish living organisms from nonliving things and things no longer alive.
- Indicate changes that take place in each season of the year.
- Describe the function of the skeleton in terms of protection and support for animals with and without backbones.
- Give at least one example of how plants have adapted to their environment.
- Construct three simple food chains including one involving the human being.
- Identify, in sequential order, pictures of stages in the life history (cycle) of common animals.
- Explain the role of blood, blood vessels, and the heart in circulating food and oxygen to all parts of the body and in removing wastes from body cells.
- Identify, in sequential order, pictures of stages in life history (cycle) of human beings.
- Explain how a human being brings oxygen into its body.
- List at least three factors that limit the number of plants and animals surviving in each generation.
- Arrange, in sequential order, pictures of stages in the life cycle of a common plant, e.g., bean, dandelion.

Concept objectives in physical science

Major Concept: The physical world consists of matter and energy interacting.

- Identify from a collection of substances those which are solids, liquids or gases.
- Cite evidence that heat, light and electricity are forms of energy.
- Furnish at least one kind of evidence indicating the pressure of air.
- Locate the relative position of the sun, earth and moon in our solar system and indicate awareness of seasons and also moon phases.
- Identify, from a group of objects, those which are good or poor conductors of electricity.
- * Describe a change that takes place as the result of a common chemical reaction, e.g., vinegar and baking soda, lime water and carbon dioxide, rusting of iron.

*Concept objectives in earth science

*Major Concept: The universe is constantly changing.

- *● Describe the motion of the planets around the sun and the satellites around the planets.
- *● Define rotation and revolution.
- *● Explain changes in the earth's surface—such as erosion, earthquakes, volcanos.
- *● Contrast the differences among sedimentary, igneous and metamorphic rocks.
- *● Explain how solar energy is transformed into other forms of energy on earth.
- *● Describe one role of condensation, evaporation and precipitation in weather changes.

Skill objectives in science

- Measure length to the nearest scale graduation.
- Read a thermometer to the nearest graduation.
- Collect and record data from experiments and activities.
- Use a hand lens to observe detail not easily distinguishable to the naked eye.
- Identify and classify objects using odor, taste, sound and sight.
- Make predictions and verify accuracy, e.g., do seeds germinate better in light or dark?
- Weigh oneself to the nearest graduation on the scale.
- Classify animals and plants based on the likenesses and differences that exist among them, e.g., structure, habitat, etc.
- Operate a beam balance (seesaw).
- Sort and group objects by their properties.
- Make simple quantitative estimates and verify them, e.g., estimate the number of beans in a jar.
- Make sketches from observations.
- Identify those factors which must be kept constant during an investigation.
- Demonstrate skill in feeding and caring for a living animal over a period of time.
- Demonstrate skill in propagating plants and caring for them over a period of time.
- Make a simple electric circuit, given a wire, bulb, and battery.

Attitudinal objectives in science

- Demonstrate the value of following the rules of safety.
- Exhibit self-confidence through the study of science by being involved in a variety of scientific activities.
- Accept evidence gathered through scientific methods.
- Demonstrate individual curiosity and persistence in the study of science.

Science Objectives
For Students Completing Grade 8

Concept objectives in life science

Major Concept 1: Living organisms carry on life functions.

- Illustrate that living organisms have life cycles, e.g., birth to death, seed to mature plant.
- Distinguish between living and nonliving things by describing life functions.
- Discuss health as the absence of disease.
- Show that disease may be prevented by the good health habits of eating, resting, exercising, and hygiene.
- Describe the differences in the structure and functions of cells, tissues, and organs.
- Find patterns in data, events, and life itself.
- Explain the process of photosynthesis and its dependence upon such factors as light energy, chlorophyll, water and carbon dioxide.
- *● Explain how "like tends to beget like" (genetics).

Major Concept 2: Living organisms and their environment are interdependent and are constantly interacting.

- Illustrate and describe the water cycle.
- Explain the predator-prey relationship.
- Give reasons for the need to conserve soil.
- Compare, contrast, and discuss food chains and food webs.
- Define symbiosis and give examples of this relationship.
- Explain the carbon-hydrogen-oxygen cycle.
- Describe the nitrogen cycle.
- Explain what soils are and how they are formed.

*Major Concept 3: Living things change.

- *● Explain that the environment is always changing and organisms must be able to adjust to these changes in order to survive.
- *● Describe how each plant and animal goes through a series of changes as part of its individual life cycle.
- *● Describe how living things have changed over the long period of earth history.
- *● Discuss how many plants and animals have been unable to adapt to changing environments and have become extinct.
- *● Describe fossil evidence that indicates that many forms of life (e.g., trilobites, dinosaurs, and sabertooth tigers) have become extinct.
- *● Describe how organisms and their environments are constantly interacting and are interdependent. (The activities of plants and animals can change the environment and changes in the environment can affect plants and animals.)
- *● Explain how changes in structure and behavior from one generation to the next are usually the result of genetic changes.

Concept objectives in physical science

Major Concept: The physical world consists of the interactions of matter and energy.

- Give examples of different forms of energy.
- Identify the three basic parts of an atom, their charges and relative locations.
- Give examples of chemical changes, e.g., rusting of iron.
- Differentiate among solids, liquids, and gases, and describe their properties by using the kinetic molecular theory.
- Relate how an energy change is involved whenever there is a change in the state (phase) of matter, e.g., water to steam, etc.
- Describe how forms of energy may be changed into other forms of energy.
- Define a calorie and differentiate between small and large calories.
- Demonstrate an awareness that atomic energy results from the conversion of nuclear mass into energy.
- Identify sources of nuclear energy and compare fission and fusion.
- Differentiate among and give examples of the following forces: adhesion, cohesion, capillarity, surface tension, gravity and friction.
- Explain some of the factors which affect electricity as a flow of electrons.
- Explain the relationship of temperature to the kinetic molecular theory.
- Define and illustrate the differences between kinetic and potential energy.
- Describe patterns in the Periodic Chart of the Elements.
- Explain that density is the relationship between mass and volume.
- Define and distinguish between mass and weight, and between mass and volume.
- Explain how electrical energy can be used to operate devices such as the radio, telephone, computer, etc.
- *Describe how sound is formed, transmitted and received.
- *Contrast reflection and refraction.
- Describe how white light is formed by and may be divided into many colors.

Concept objectives in earth science

Major Concept: The earth and the solar system undergo changes involving different cycles.

- Describe the changes which occur in stars.
- Plot the path of a planet across the sky.
- Explain a solar and a lunar eclipse.
- Describe how the moon influences the tides.
- Explain how the sun affects the earth's climate and weather.
- Describe the methods by which sedimentary, igneous and metamorphic rock are formed.
- Contrast various kinds of weathering.
- Explain how sedimentation affects the ocean floor.

Skill objectives in science

- Use measuring devices and record data properly.
- Make graphs and charts from the data given.
- Interpret data, charts, and graphs, and make generalizations.
- Follow directions to utilize simple tests and interpret results.
- Employ mathematics necessary to convert units within the metric system.
- Develop a hypothesis from basic data and devise a method to test it.
- Use, maintain, and care for laboratory equipment.
- Distinguish between qualitative and quantitative observations.
- Follow laboratory safety rules at all times.
- Use "scientific methods" for setting up experiments which have dependent and independent variables.
- Communicate information organized in logical sequences orally and graphically using related vocabularies.
- Recognize that certain teaching devices, such as a "model," are only aids and are not reality.
- Apply scientific theories and laws to a given situation.

Attitudinal objectives in science

- Follow the rules of safety in the science laboratory.
- Appreciate that science is a way of looking at the universe, at life, and is a part of life.
- Show respect and appreciation for all living organisms.
- Appreciate how science is related to one's world.
- Respect and appreciate the environment based on knowledge.
- Appreciate the value of critical thinking.
- Appreciate the value of scientific instruments as extensions of the senses.

Science Objectives
For Students Completing Grade 12

Concept objectives in life sciences

Major Concept 1: All living things have basic needs.

- Discuss the fact that living things must have water and nourishment, respire, and reproduce to continue the species.
- Discuss the proper care of laboratory animals and treatment of domestic animals and wildlife.
- Discuss the proper care of plants in the laboratory, greenhouse, at home, out-of-doors and the importance of preserving wildflowers, plants, bushes, and trees.

Major Concept 2: Knowledge of the dynamics of ecology is essential for intelligent planning and decision making.

- Define an ecosystem and compare biotic and abiotic factors.
- Describe adaptions of organisms for survival in a particular ecosystem.
- Identify and describe a predator-prey relationship.

Major Concept 3: Living things require energy and there must be an interchange of energy in a balanced environment if living things are to survive.

- Explain the relationship among producers, consumers and decomposers.
- Compare and contrast photosynthesis and cell respiration.
- Explain the relationship between a food chain and a food web.

Major Concept 4: The cell is the basic structural and functional unit of most living things.

- Explain the relationship among cells, tissues, organs and systems.
- Make comparisons between plant and animal cells.
- Identify the organelles of the cell and explain their functions.
- Compare and contrast mitosis and meiosis and explain the purpose of these processes.

Major Concept 5: A pattern of inheritance can be observed over a period of time.

- Explain the difference between asexual and sexual reproduction.
- Illustrate the Mendelian Laws of Inheritance.
- Describe the chemical nature of genes and chromosomes and their role in maintaining genetic continuity.
- Discuss the benefits and dangers of genetic engineering.

Major Concept 6: Correct information about the human body will aid the individual in daily life and make one a more efficient and responsible human.

- Explain the structure and function of the human body systems.
- Discuss the following as they relate to health.
  a. human growth and development
  b. hygiene
  c. drugs, alcohol, and nicotine
  d. nutrition
  e. food additives and imitation foods

Major Concept 7: Some microorganisms cause disease and others are beneficial.

- Discuss the role of bacteria in health and disease.
- Explain the methods by which pathogenic organisms can be transmitted.
- Explain active immunity and how it is acquired.
- Compare and contrast bacteria, viruses, fungi, and molds.

Major Concept 8: There is an increasing order of complexity in living organisms.

- Select two animals from different phyla and compare structures and how the animals carry on life functions.
- Select two plants ranging from algae to angiosperms and compare structure and how the plants carry on life functions.

Concept objectives in physical science

Major Concept 1: Matter is composed of molecules, atoms, or ions whose interactions, when observed and measured, are found to follow natural laws.

- Distinguish between atoms and molecules.
- Distinguish among elements, compounds, and mixtures.
- Identify the physical state (phase) of a substance.
- Locate protons, neutrons, and electrons in the present model of the atom and state the charge on each.
- Describe how molecules are composed of atoms bonded together.
- Substantiate that chemical reactions result in new substances with new properties.
- Explain why and how in ordinary chemical reactions, the total mass of reactants must equal the total mass of products.
- Describe general properties of acids, bases (alkalis), and salts and describe neutralizations.
- Compare and contrast a physical and chemical change.
- Explain how an ion is a charged particle and an atom is a neutral particle.
- Identify the solute and solvent in a solution.
- Explain the relationship between atomic structure and the properties of the elements.
- Identify the symbols of "common" elements.
- Distinguish between simple organic and inorganic compounds.

Major Concept 2: Energy exists in many forms which are interconvertible through reactions with matter.

- Differentiate between situations illustrating kinetic energy and potential energy.
- Explain the effect of temperature on the physical state (phase) of a substance.
- Substantiate that chemical reactions are accompanied by energy changes.
- Explain the difference between temperature and heat.
- Predict the effect of a temperature change and of pressure change on the volume of a gas.
- Explain the relationship between molecular motion and temperature.
- Explain the relationship between molecular motion and pressure.
- Define what is meant by a gas, liquid, and solid in terms of the proximity and relative motion of their particles and in terms of their size and shape.
- Define work and do simple problems involving work.
- Define velocity and speed.
- Define and give examples of forces.
- Describe the factors that influence the rate of a chemical reaction.
- Explain the phase changes associated with the melting point and with the boiling point of a substance.
- Define electricity.
- Explain the ways in which static electricity, alternating current (AC) and direct current (DC) differ.
- Cite evidence that, under ordinary circumstances, matter and energy can

be converted from one form to another with no loss or gain.

- Explain how simple machines operate.
- Define acceleration.
- Explain the relationship between the quantity of material and the heat content of the substance.
- Define friction and give examples of its advantages and disadvantages.
- Cite evidence that matter and energy are interconvertible but the sum total of these remains constant.
- Describe sound and explain it as a form of energy.
- Discuss the electromagnetic spectrum.
- Explain electromagnetic radiation as a form of energy.

Concept objectives in earth science

*Major Concept: Geological, meteorological, oceanological, and astronomical processes follow physical laws.

- Define the study of astronomy as relating to galaxies, star systems, and space.
- Illustrate that geology concerns itself with historical geology, the story in the rocks, earth chemistry, and the restless earth.
- Discuss the limits of the earth's energy resources.

Table 2
Basic Science Concepts, Skills and Attitudes
For Students Completing Grades 4, 8 and 12
In Connecticut Schools

	GRADE 4	GRADE 8	GRADE 12
LIFE SCIENCES	Living things respire, need nourishment and water, and reproduce their own kind.	● Living organisms carry on life functions. ● Living organisms and their environment are interdependent and are constantly interacting. *● Living things change.	● All living things have basic needs. ● Knowledge of the dynamics of ecology is essential for intelligent planning and decision making. ● Living things require energy and there must be an interchange of energy in a balanced environment if living things are to survive. ● The cell is the basic structural and functional unit of most living things. ● A pattern of inheritance can be observed over a period of time. ● Correct information about the human body will aid the individual in daily life and make one a more efficient and re-

- Recognize the dynamic nature of the earth.
- Explain how oceanography concerns itself with salinity of oceans, marine biology, marine topography, and motions of tides, waves, currents and shorelines.
- Discuss how meteorology is concerned with weather, air, and its movements, chemical and physical properties of gases, air masses, motion caused by the sun's energy, weather maps, and forecasting.
- Discuss the energy source for earthquakes, thunderstorms, ocean currents and starlight.
- Illustrate and explain the rock cycle.

Skill objectives in science

- Interpret results.
- Set up controls or standards.
- Communicate acquired knowledge graphically, quantitatively, and verbally.
- Use the specific vocabulary related to each topic under study.
- Demonstrate skill in the use of appropriate techniques, instruments, equipment and test kits within each discipline as required.
- Select and assemble appropriate equipment and conduct experiments.
- Make necessary observations and record the data in an appropriate and logical format.
- Consider alternative solutions.
- Identify a problem and state it clearly.
- Examine the literature for ideas related to the problems.
- Design experiments and define variables.

Table 2(continued)

	GRADE 4	GRADE 8	GRADE 12
LIFE SCIENCES			sponsible human. • Some microorganisms cause disease and others are beneficial. • There is an increasing order of complexity in living organisms.
PHYSICAL SCIENCES	The physical world consists of matter and energy interacting.	The physical world consists of interactions of matter and energy.	• Matter is composed of molecules, atoms, or ions whose interactions, when observed and measured, are found to follow natural laws. • The natural world operates according to identifiable physical laws. • Energy exists in many forms which can be converted from one to another.

Attitudinal objectives

- Be aware of the importance of biology as a study of living things and how it relates to oneself.
- Develop appreciation for critical thinking as used in the practice of science.
- Demonstrate a willingness to cooperate in class and laboratory.
- Appreciate that one's genetic characteristics and environmental factors work together to comprise the individual's total being.
- Develop attitudes that are built upon fact and logic.
- Demonstrate a better understanding of the advantages and problems in the everyday world by society's use and misuse of scientific knowledge.
- Appreciate the potential for careers in the sciences and science-related fields.
- Observe rules of safety in the laboratory and field.
- Demonstrate a belief that the physical universe obeys specific laws.
- Appreciate the relationship of concepts studied to the everyday world.
- *Appreciate that different points of view develop when citizens must make decisions on problems involving science.
- Demonstrate the development of a personal value system regarding the environment by willingness to adjust one's lifestyle to be in harmony with ecological laws.
- Appreciate and visualize the space-time relationships associated with earth and science.

Table 2 (continued)

	GRADE 4	GRADE 8	GRADE 12
EARTH SCIENCES	*The universe is constantly changing.	The earth and the solar system undergo changes involving different cycles.	Geological, meteorological, oceanological and astronomical processes follow physical laws.
SKILLS	Classification Measurement Prediction Manipulation Estimation Observation	GRADE 4 Skills Plus Graphing Interpretation Hypothesizing Communication Recording Data	GRADE 8 Skills Plus Controlling variables Formulating problems Designing experiments Considering alternatives
ATTITUDES	Curiosity Persistence Self-confidence Following of rules of safety	GRADE 4 Attitudes Plus Respect for living things Respect for environment Value of critical thought Relation of science to society Science as a method of looking at the world	GRADE 8 Attitudes Plus Appreciation for critical thought Potential for careers in science and technology Adjust life styles to environmental needs Understanding of use of scientific knowledge

Science for Students With Special Needs 5

Every Connecticut school district must offer a free, appropriate public education for students between the ages of three and 21. A major feature of this requirement is the emphasis on the regular classroom as the preferred instructional base, whenever appropriate. This philosophy or approach to educational programming for handicapped children is termed the principle of the least restrictive environment.

As school systems began implementing the least restrictive environment concept, the term "mainstreaming" became a part of our vocabulary. "Mainstreaming," in practice, means the social and instructional integration of exceptional children with other children. There are specific criteria which guide mainstreaming. Whenever appropriate, handicapped children should be educated in regular classrooms. Special education staff should consult with the classroom teachers on a regularly scheduled basis to help plan activities, demonstrate special materials, or suggest specific approaches to be used when working with children who have special educational needs.

Handicapped children include those:

- with mental handicaps
- with physical handicaps
- with visual and auditory impairments
- with behavior disorders whether emotional disturbance or social maladjustment
- with learning disabilities and communication disorders
- with multiple and severe handicaps

The school district's planning and placement teams may decide to educate certain, more severely handicapped students in special classes or separate programs when the student would be unable to properly participate in the regular program even with possible modifications. References to publications and organizations dealing with handicapped youngsters appear in Appendix H.

The classroom teacher and mainstreaming

Some classroom teachers of science without special education training may be uneasy about having a handicapped student in their classes. Once reasonable modifications to the course have been made, the programs are usually successful and the integration of the handicapped student provides a rewarding experience for both teacher and student. Through placement of the handicapped child in the least restrictive environment, other students notice the similarities, as opposed to the differences, between themselves and the handicapped student. Children in the class are richer because of this type of experience.

The physically handicapped child

At a recent conference of science educators on the physically handicapped student and science, convened by the National Science Teachers Association (NSTA), it was concluded that science courses should be an integral part of the education of handicapped students from kindergarten through the high school. These students should receive the same comprehensive exposure to the fields of science as do the regular students. The curriculum for handicapped students should include content, process and career education. Instructional strategies, techniques and procedures found to be effective with the nonhandicapped student are those also found to be effective with the physically handicapped student. Recommendations from the conference included:

- Career Concerns—Handicapped students should have equal opportunities to pursue science-related careers.
- Teacher Education—Preservice education programs should prepare prospective classroom personnel to teach science to handicapped students. In-service programs should provide school personnel access to current information on teaching science to handicapped students.
- Methods—Methods used in teaching science to physically handicapped students should provide opportunities for them to learn how to be independent learners and how to interact with nonhandicapped persons.
- Materials/Programs—Special considerations should be given to the identification and development of instructional materials/programs that will help eliminate the barriers to the study of science for physically handicapped students.
- Dissemination—In order for classroom teachers and counselors to plan and implement desirable science programs for physically handicapped students, it is essential that they have ongoing access to current and relevant information.
- Evaluation/Assessment—In the absence of a body of empirical knowledge on teaching science to handicapped students, systematic efforts to gather, organize, synthesize and disseminate this knowledge should be conducted.
- Education Organizations and Agencies—Each professional education organization and agency should be actively concerned with the rights and needs of physically handicapped students to be taught science in an appropriate classroom setting.

Most current science programs can be used by the physically handicapped student. However, there is one project—Science Enrichment for Learners with Physical Handicaps (SELPH)—which is an adaptation of the Science Activities for the Visually Impaired (SAVI) project and which produces units of study and equipment for the orthopedically disabled child.

The learning disabled child

There are a number of diagnostic terms which fall under the heading of learning disability. Elaboration upon these numerous diagnostic terms is beyond the scope of this guide.

Some broad guidelines for working with these children can be given. For example, when working with a learning disabled student the teacher must know the child well, know his/her strengths, personality and learning styles. Parents, doctors, special education specialists and administrators can assist in identifying the problem areas with which the child needs help. Once these are identified special materials or approaches may be developed.

At the present time there are no special science programs for the learning disabled child. This is why it is so important that the teacher know the child's learning needs, as identified by the planning and placement team. With this kind of information, the teacher can design alternate learning exercises.

Mentally retarded children

Children who are classified as mentally retarded exhibit development lags in general maturation, cognitive ability and social adjustment. The vast majority of children with mental retardation are mildly handicapped, and can benefit from much of the regular program. Usually it takes these students more time to learn some fact or concept, and they may be unable to retain as much material as other children. These students often have difficulty recalling, transferring, conceptualizing and generalizing. These handicaps have important implications for teachers who are planning science programs.

When modified programs are created for these students, the teacher should make certain that concrete and firsthand experiences abound. The program should be flexible enough to follow the child's curiosity whenever possible and appropriate. Activities should not be solely dependent on the child's ability to read. The activities planned should be such that they usually allow the student to complete the activity and be successful.

The Biological Sciences Curriculum Study (BSCS) Group, located in Boulder, Colorado, has developed a life sciences program to meet the need of mentally retarded student in the upper elementary and junior high school grades. This program has three main parts, "Me Now," "Me and My Environment," and "Me in the Future."

It is interesting to note that several school systems have adapted the American Association for the Advancement of Science program, *Science—A Process Approach* (SAPA), for use with educable mentally handicapped students. The hierarchy of skills presented and developed, plus the defined sequence of this program makes it suitable for use with these children.

The deaf and hearing impaired child

All children need to explore their environment and wonder about it. The natural inquisitiveness of children is not impaired by a hearing loss.

Once again, most science programs in the marketplace can be used with deaf children. Of course some adaptations may have to be made in some of the activities. This would be especially true in certain units dealing with sound. The teacher may have to do more writing on the blackboard. Instructions for certain activities may have to be acted out or illustrated by models, pictorial representations, printed words, or in rebus form. Task cards may be used for the children who can read.

As mentioned above, existing commercial science programs can be adapted for use with deaf children. The *Science Curriculum Improvement Study* (SCIS) program has a version that has been adapted for deaf children.

The blind or visually impaired child

When working with blind or visually impaired children many procedures should be tried. Some of these procedures are described below.

- Stress tactile and auditory conversations in science work. Children can also uncover information about objects through smell or taste.
- Whenever possible, blind or visually impaired children should participate in science work along with sighted peers. Pairing children is often a successful strategy.
- Sufficient opportunities for free and individual investigations should be provided. Blind children often need a greater amount of time to explore objects than their sighted peers. As children get to know a variety of objects well, their confidence and independence will grow.
- Adapt exercises or activities so that blind children can participate in them, e.g., instead of sorting objects from a kit according to purely visual characteristics, the blind child can accomplish the goal of sorting by grouping the objects by shape, sound, texture, odor, etc.
- Instructions for activities can be provided using tape recorders, braille labels (if available), or directions read to blind students by the teacher or another student. When providing instructions either orally or on tape, it is best to use terms that are already familiar to the child.
- Language development can be encouraged while the child is manipulating an object or performing an operation (e.g., as a child feels a block, he/she should be asked to describe it fully). If new terms are to be provided, they should be done clearly and while the child is experiencing the meaning, sensation, or characteristic associated with the word.
- Successful experiences should be planned in order to build independence. While praise should not be given indiscriminately, it should be provided often enough to sustain and build growing confidence.
- Materials to be used with blind children should be selected with great care so as to provide maximum sensation while taking precautions not to introduce dangerous (e.g., sharp or pointed) objects.

A new science program for the blind called Science Activities for the Visually Impaired (SAVI) is currently under development by a group of educators, under the direction of Dr. Herbert Thier, Lawrence Hall of Science at the University of California in Berkeley. This group has developed science teaching units as well as the equipment to supplement these units.

Science for the gifted

One of the major problems facing teachers today is how to provide for the gifted child within the basic science curriculum. Most programs for the gifted tend to focus on language arts activities, reading and art experiences. The special needs of these students in the curricular areas of science and mathematics are frequently neglected. It has been recommended that since the multitalent approach to identification of the gifted (above average ability, task commitment, creativity) is now widely advocated (see Appendix H), it makes some sense to provide special learning experiences for the gifted in relation to their areas of high potential. This means that the student with high science ability should be steered toward a special science program and the gifted art student to that area and so on. The danger of this approach is the possibility of too narrow a focusing of instruction only on a gifted student's high ability area. This may prove to be counterproductive to the individual's general intellectual development. Many gifted children have special abilities in a variety of areas and a program designed too rigidly may limit the number of opportunities that could be made available.

A well-designed gifted program should provide opportunities for both broad general development of the individual and for areas of specialization such as science. Thus, there is a need for program growth in two dimensions: breadth and depth. A well-trained resource teacher can fill the need for providing a creative enrichment program involving thinking skills, aesthetics, problem-solving and project activities. Meanwhile, the focus on depth may come from programs which allow the opportunities for specialized study in a curriculum area.

Specialization programs for the gifted may mean three different things: acceleration, enrichment and a method of grouping.

Acceleration. Acceleration or advancement refers to the old idea of leap-frogging ahead or skipping of grades. This can also mean early admission to kindergarten or 1st grade, or perhaps a compressed high school curriculum that permits students to graduate a semester or full year ahead of schedule. It may also mean an in-depth study of more challenging topics, more thorough learning of regular topics, or extension of the subject matter or correlated areas.

There are other methods of acceleration that may reduce the social and emotional problems that can occur when a child is moved into classes with older children. A 3rd grader who is a whiz in arithmetic might go to the 6th grade classroom for mathematics but spend the rest of the day with his/her 3rd grade peers. (This semiseparation approach is practiced by many schools in Connecticut.) Or a high school student may be released from school part-time to attend courses at a local college.

Enrichment. Instead of using the existing school structure to provide challenges for the gifted, enrichment offers different types of learning opportunities. The learning process can be enriched by different curriculum materials, individual instruction, emphasis on the higher mental processes of divergent thinking and creativity, independent study, problem-solving projects with real products and any number of techniques that give gifted youngsters a welcome change from the routine of the regular classroom. But a difference in curriculum is not sufficient for the gifted science student, rather a challenging difference is what is required.

Individual instruction may come from the regular teacher in the classroom or be provided by specially trained teachers in "resource rooms" where the gifted and talented in a school (or a city) spend time with their particular interests. In some school districts a resource room may be staffed by a teacher who travels from school to school.

Another form of enrichment is a mentorship program through which local citizens, such as scientists, artists or business people, work closely with gifted children, sharing expertise with them and fostering the students' talents.

Grouping. This is sometimes considered a controversial approach to needs of the gifted. Some critics feel that separating bright children from the others fosters a sense of elitism and prevents the "average" students from learning from their more talented classmates. Advocates say that the gifted may learn more if they are grouped with their intellectual peers and receive the essential challenge provided by other bright students.

As with acceleration, grouping can be accomplished in a variety of modes. Some school districts provide complete separation, with special schools or special classes within a school that the gifted and talented attend full-time (e.g., The Bronx High School of Science and the new High School for the Gifted and Talented in North Carolina). More commonly, arrangements are made to allow all gifted students in a particular grade to be placed in the same class but not with the entire class population. This method is the one most frequently used in Connecticut's schools. Students spend part of their day with their classmates but the rest of the day with other gifted students who may be younger or older.

Grouping may really be considered another form of enrichment. It can involve such things as special Saturday classes, summer programs at universities and field trips or other special projects outside regular school hours (e.g., the Talcott Mountain Science Center, Saturday and summer programs; Project Oceanology, etc.).

Whatever the approach or combination of approaches, a really good quality gifted program should offer both a creative enrichment and a specialization of study. Both are essential for a full and maximum development of the gifted child. Creative enrichment cuts across all areas of special talent while specialized study provides a focus for a student's special abilities. A vital criterion for any special program is that it truly gives the student a significant challenge and is not simply busy work. The work should be more advanced and exciting and permit delving into subjects in depth. It should also encourage independent learning.

School Science Facilities 6

The science facilities required in the elementary school, as at any level, are as limitless as a teacher's imagination and budget. Obviously, it is impossible to anticipate the diversity that ideally occurs. However, there are several common elements needed to conduct an efficient activity-centered program in any school. Regardless of the science program implemented, it is desirable to make the facilities as flexible as possible to accommodate large and small group instruction, independent study activities, personalized programs, and changes necessitated by an evolving curriculum of science for the future.

Realizing the financial stress that new curricula and associated facilities put on the budget of a school system, many of the newer curricula for the sciences are designed to function under existing education environments. In the public schools of Connecticut, the K–5, K–6 or the K–8 sequence is used in approximately two-thirds of the elementary schools, with the majority following a K–6 structure. Since the K–6 program predominates at the national level, elementary science curricula have been organized around this K–6 core. Most of the programs assume that elementary school teachers are not science specialists and that they teach in self-contained classrooms. Science is usually taught in an elementary classroom and is structured around intraclass activities performed by individuals or small groups. The science units and individual lessons are developed around common materials which do not entail unusual or elaborate equipment. Therefore, a teacher or aide can assemble the necessary learning materials from local sources in the community or the surrounding area. It is also possible to purchase kits or prepared lessons from the various educational supply houses. The advantage in the commercially packaged units is that less time is required to gather materials. Most units come in their own containers which are suitable for classroom storage.

Science should be an integral part of the elementary school program. The materials and activities should not be isolated from normal class activities. However, the classroom should provide the following: a section for storage of nonperishable substances; an area exposed to sunlight; facilities for animals required for extended observations; a work area for students to do individual or personalized science activities; a portion of the room allocated for the retention of experiments that extend over several days, and means for obtaining and discarding water. Any experiments requiring electricity, such as in the Elementary Science Study (ESS) unit, *Batteries & Bulbs*, can use common batteries or dry cells. In units needing heat, candles or hot plates can be used. Once these preliminary materials are obtained, the room will be equipped to provide a continuing program regardless of the curriculum.

In schools where the classrooms are self-contained, the following room organization suggests one arrangement of the facilities for carrying on the elementary science program (see Figure 1).

When school systems allocate particular segments of the day for science, the entire classroom can quickly be restructured to meet the needs of the particular lesson, but when the curriculum is structured around the open-class concept, space requirements are substantially increased. Facilities must continuously provide a diversity of readily accessible lessons; work areas that range from desk tops to sinks; several disposal areas appropriate for materials consumed; and the organization to meet the demands of fluctuating numbers of students engaged in a variety of science investigations all at different stages of completion.

One disadvantage in using the typical elementary classroom is the difficulty in

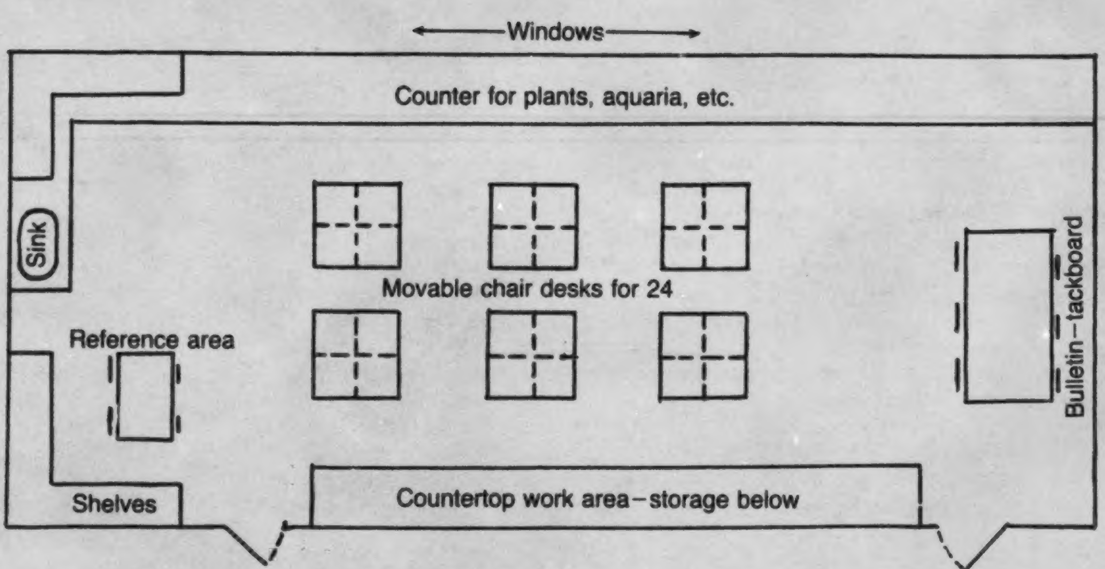
Windows
Counter for plants, aquaria, etc.
Sink
Movable chair desks for 24
Reference area
Bulletin–tackboard
Shelves
Countertop work area–storage below

Figure 1

Possible Classroom Arrangement For Science

conducting individualized or personalized experiments. To provide for such individualization, some schools have adopted a science program under the guidance of a science coordinator or consultant. This individual directs a science center with the assistance of other members of the staff.

An alternative is to have the consultant use the teacher's room for the various lessons and the center for special activities.

The center itself may be an area used primarily for consolidation of materials and equipment and the dissemination of packaged lessons for daily or weekly use. It may also be a work area containing electrical, gas, and water outlets. Along with these facilities, there is usually sufficient table space and room for several diverse activities to be conducted simultaneously. The science center has other advantages in that it can provide the opportunity for students to conduct experiments without disturbing other students. The center could be open on a continual basis enabling students to do experiments during the day as their schedule permits. The floor plan shown in Figure 2 provides one means of organizing a science center.

A science center enables a school system to purchase materials for a particular curriculum without duplicating units for every classroom. Some centers

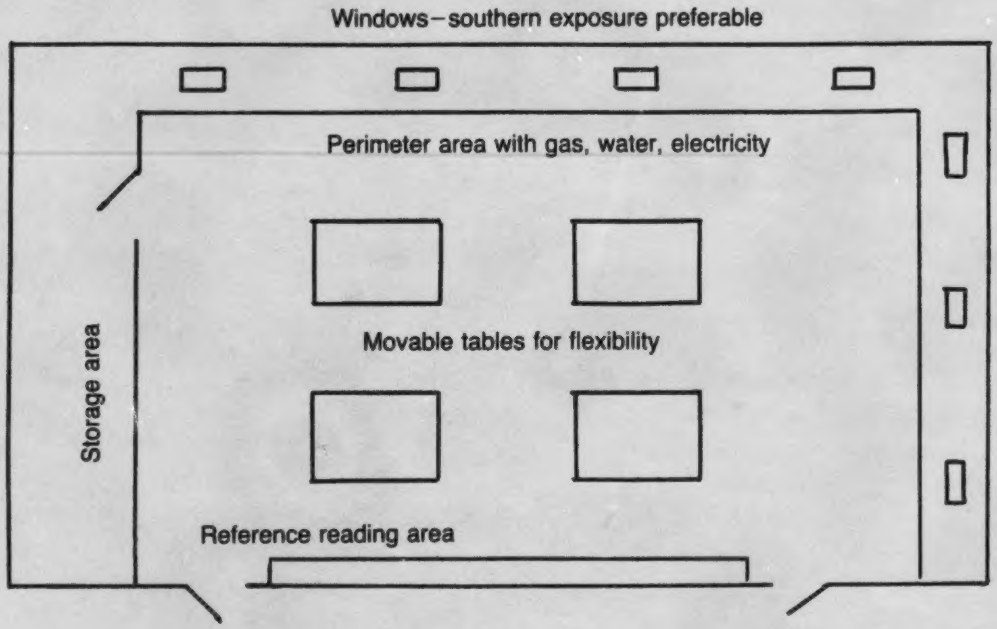
Windows–southern exposure preferable
Perimeter area with gas, water, electricity
Movable tables for flexibility
Storage area
Reference reading area

Figure 2

Possible Floor Plan For A Science Center

contain room for activities from the newer curricula to further stimulate personalized science investigations.

In an attempt to use many forms of learning experiences, some systems have established learning centers with a nucleus consisting of a library and reference area shown in Figure 3. The science facilities contain all the advantages of a science center, and audiovisual and other materials are easily accessible without taking up valuable laboratory space. The learning center also enables students to conduct investigations in one area and momentarily go to another room or center for supplementary information or materials.

In light of the many new science curricula already available, it is important that facilities in elementary schools be made available to accommodate the curricula. These facilities will depend upon the philosophy of the school and its approach to instruction.

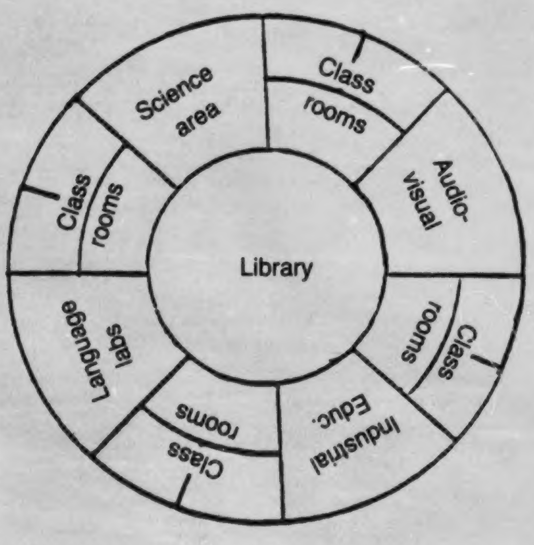
Science area
Class rooms
Audio-visual
Class rooms
Industrial Educ.
Class rooms
Language labs
Class rooms
Library

Figure 3

Learning Center Established In Some Systems

Secondary school science facilities

There are certain general considerations to keep in mind when planning high school science facilities.

Flexibility. Science facilities should be planned for the existing curriculum but with sufficient flexibility to meet the needs of the future. Multipurpose labs, and flexible, movable lab tables and benches are preferable to massive, stationary lab furniture.

Room size. Room size should be variable and planned for a wide range of activities from seminar-type rooms to accommodate five to ten students to large lecture-activity rooms seating 100 to 150 students. Availability of space for individual work or long-term projects is desirable.

Storage facilities. Centralized storage facilities are quite common in newer buildings. Laboratory aides or technicians may work in this area to supply the needs of all labs and individual student projects. In designing the science area, decentralized storage facilities may have advantages by lessening the movement of apparatus and equipment necessary. It is desirable to have most of the equipment and materials in the room where the apparatus is to be used, but much equipment, because of expense or limited use, may be shared and some adequately ventilated central storage area is probably desirable. Storage spaces between science rooms for convenience should be considered. Open shelving, rolling carts and racks are handier and less expensive than enclosed cupboards and cabinets.

Specialized rooms. Plant rooms, animal rooms, self-study carrels, and independent study areas are desirable features to be incorporated in new science areas. In-room library areas with magazines and reference materials can be designed to make these materials readily available.

Laboratory arrangements

The possible arrangements for laboratory layouts are practically endless. However, most laboratory arrangements follow three general patterns. These are the perimeter, the island, or the long, straight-table type. Each style has certain advantages and should be studied carefully before making a final selection. However, in accordance with NSTA guidelines, it is recommended that there be a minimum of 45 square feet (5.5 square meters) per student in a classroom laboratory.

The perimeter layout locates the laboratory workspace around the walls of the room. This may be a straight-table type or there may be tables placed perpendicular to the walls to give additional space. Water, gas, and other desired service is available to all stations. With movable tables or tablet arm chairs in the center of the room this setup has much flexibility for various activities (see Figure 4).

The island-type of laboratory space may have rectangular, square, or octagonal-shaped tables. These may be serviced from an island which is permanently (or in some new laboratories, temporarily) located in the room, but the tables are movable so that different arrangements are possible. A separate area is available for tables or chairs for nonlaboratory activities.

The long, straight-table type laboratory bench with service pipes and trough sinks running the length of the table to service students on both sides of the bench is the style most common for many years. There is little flexibility to this setup and it is not often seen in newer buildings.

Biology laboratories are commonly of two different types. One type utilizes long tables with sinks and facilities in the middle. The students sit on stools running along the sides of the table (see Figure 5). A modified perimeter arrangement is also used such as shown in Figure 4. Either 30-inch (.76m) desk tops using standard height chairs or 36-inch (.91m) table tops with tall stools are used.

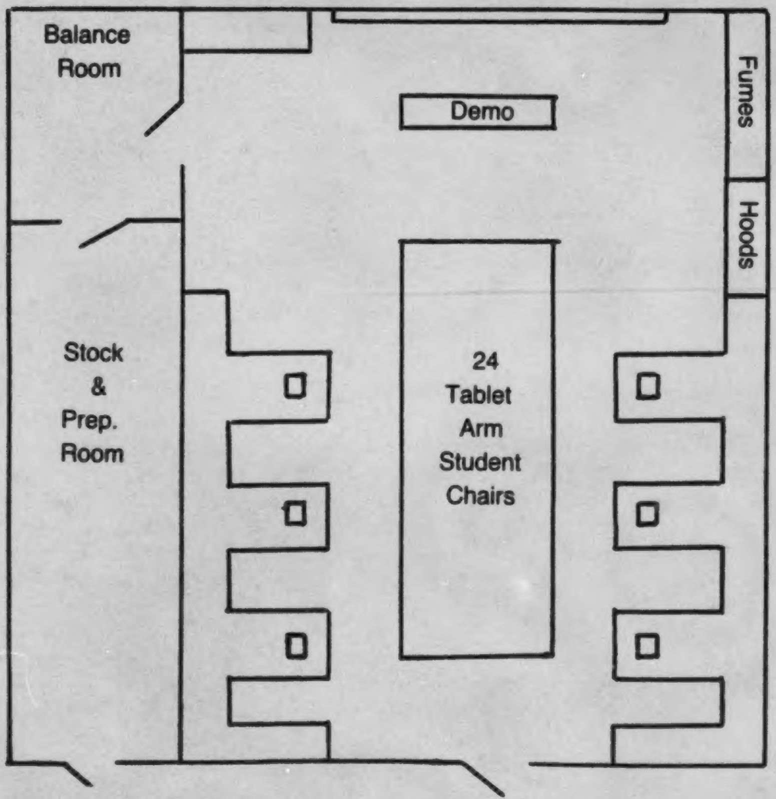

Figure 4

Typical 24-Student Chemistry Classroom Laboratory

Types of lab activity

Some laboratory activities are best accomplished with the student seated at a standard table with a height of 30 inches (.76m). Many biology experiments use this table height. Most chemistry experiments are performed with the students standing at a bench with a height of 36 inches (.91m). Stools or chairs and table of the proper height allow both standing and sitting activities to be pursued comfortably. Combining a perimeter setup for standing activities with islands or tables for sit-down activities gives great flexibility.

Lecture-labs vs. separate laboratories

It is well established that science courses should be laboratory-oriented. Many chemistry, physics, and biology courses meet for four or five lecture periods and one double period for laboratory each week. In the newer programs, laboratory activities may be conducted three or four times a week, a schedule requiring

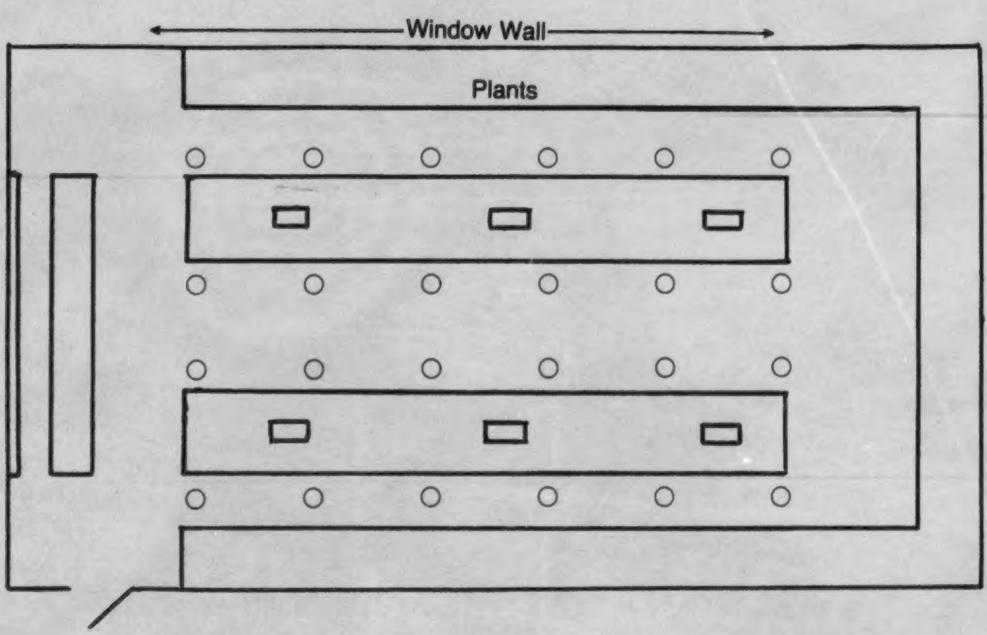

Figure 5

Typical 24-Student Biology Laboratory

that laboratory activities be possible on any day the class meets. In situations where a separate laboratory is shared by teachers, this flexibility for laboratory activities is not available.

Planning for the future

A typical junior high school with grades 7–9 will offer three years of science to all students. The courses will probably be a physical science course such as introductory physical science, a biology or life science course, and a course in earth science. The high school with grades 10–12 will probably offer biology, chemistry, and physics with various high and low sections, and possible advanced placement courses. There has been a trend to offer courses in ecology, oceanography, meteorology, and some other specialized areas.

Planetariums and computer centers are now appearing in buildings. These two facilities can be provided on a regional or a local basis through the use of state and federal assistance. Unlike some of the school facilities mentioned previously, the planetarium and computer centers have the advantage of being applicable through the entire science program, K–12. At the primary level, the planetarium serves to simulate astronomical phenomena without the reliance on hours of observations. Actual measurement and recording of data can assist a simultaneous growth in mathematics. Since most planetariums serve an entire system or region, they are rarely unoccupied.

The values of a planetarium are also present for computer centers. Presently, computer science at the K–12 level is in its infancy, but there are new computer programs being developed in all branches of science. Besides the obvious need to understand computers for anyone interested in a career in science, the facilities provide a nucleus for interdisciplinary studies with mathematics, business, and other subjects.

In planning new science facilities, a five- or ten-year projection is desirable, bringing together all the best information on town growth, student population, new courses and staff availability. Science teachers should have a significant role in planning new or renovated facilities.

Before committing any ideas on science facilities to paper, either for new construction or for the modification of a present building, it is useful to visit as many schools as possible known to have exemplary science facilities. The State Department of Education can furnish information on specific examples. Discuss the science program needs with teachers in various schools and with architects known for designing and building good facilities. The time involved in these excursions will be well spent and will result in better designed science facilities that will be functional for many years to come.

Safety in Teaching Science 7

A vital factor in planning a science curriculum for elementary, junior high and high school science programs is safety—the safety of the student in the classroom or laboratory. Teachers are responsible for the students in their care and they must be aware of the student's welfare at all times. It is strongly recommended that in the science laboratory one teacher should not be required to supervise more than 24 students.

Any science program may involve the use of materials and pieces of equipment that have the potential to injure a child, but concern for safety should neither be used as an excuse for not teaching science in the elementary grades nor to exclude student participation with equipment and materials in the junior and senior high school. What must be encouraged is an awareness of safety problems by administrators as well as teachers and students, all of whom must cooperate in the successful execution of a valid safety program. Rather than a paralyzing fear of potential catastrophe, what is to be encouraged is an awareness of hazards—after all, children are taught how to cross the street, how to obey the crossing guard, and how to buckle up seat belts! A thoughtful and calm prearrangement of plans to avoid hazards and to have a way to react in the event of unexpected occurrences can serve as the basis for a safe laboratory program which will provide the student with firsthand experiences unobtainable through other means of instruction.

Of course there are situations when, in the interest of safety, a demonstration by the instructor is called for. The teacher has to use judgment and set limits based on the student's previous experiences and the nature of the materials and equipment used for the lesson.

Remember that not all hazards can be totally eliminated. However, each teacher should try to make the science lessons as safe as possible.

Suggestions for safety in the science class

Listed below are some suggestions for safety procedures which should be used when working with science materials in the classroom.

Excerpts from the New York City schools booklet *For Greater Safety in Science Teaching* state:

- Pupils are to be under the direct supervision of a teacher at all times and in all places.
- Pupils are not to transport dangerous chemicals at any time.
- Pupils are not to handle materials on the demonstration table except under the direction of the teacher.
- Pupils are not to taste unknown chemicals or other materials except in experiments specifically designed for taste testing.
- Before permitting pupils to work with sharp tools, the teacher must be assured that pupils are fully competent to use the tools.
- At the beginning of each marking period pupils should be instructed in general safety precautions.
- Pupils should be specifically instructed at the beginning of each class period, regarding the dangers and the precautions required, where there is a special hazard. This also applies to the use of such items as hot plates, propane tanks, soldering irons, electric wires, microprojectors and audio-visual equipment. Many of these items retain heat long after use. This creates problems in storage, removal and handling. It might be wise to identify these objects with signs that warn the students these objects are hot.
- Pupils should be cautioned about hazardous activities involving the use of chemicals outside of school—e.g., mixing chemicals to "see what happens," setting fire to gasoline cans, breaking open fluorescent tubes.

The above refers primarily to students. The next set of suggestions relates to the teacher.

- When using volatile, inflammable liquids, such as alcohol, in a demonstration experiment, care should be taken that any flame in the room is at an absolutely safe distance from the liquid.
- Always add acid to water, never the reverse. (If it is necessary to prepare diluted acid, the concentrated acid should always be added in small quantities to the water, with continuous stirring.)
- Combustible materials of all types are to be kept in a metal cabinet provided with proper means for closing and locking. (Check with the Fire Department as to the type of fire extinguisher that should be in the room.)
- Do not demonstrate devices or equipment brought in by pupils before pretesting.
- In performing experiments where there is a possibility of spattering, where there is the slightest chance of a serious flash or explosion, or where the teacher deliberately uses mixtures which he/she intends to explode, the following precautions should be observed:

    1. Keep pupils at a distance not less than eight feet from the demonstration table.
    2. Use a screen of strong, fine wire mesh, wire glass, or, for spattering experiments, ordinary glass as a shield for both pupils and teachers.
    3. Whenever possible, glass vessels should be made shatterproof by cementing several layers of cellophane onto the glass with collodion. This will provide safety without affecting visibility.

4. Safety glasses or goggles *must* be worn in the science classroom when any activity is attempted which might endanger the eyes.

On inserting glass tubing into rubber stoppers or tubing, observe the following precautions:

- Never attempt to insert tubing having jagged edges. Fire-polish, if possible, otherwise level the edge with a file, wire gauze, or emery cloth.
- Use water, soap solution, glycerin, or vaseline as lubricants and force the tube into the hole by a twisting motion.
- Always aim the tubing away from the palm of the hand that holds the stopper or rubber tubing.
- Always hold the glass tubing as close as possible to the part where it is entering the rubber stopper.
- The use of a cloth wrapped around the tubing at the point of contact with the hand will help prevent injury if the glass breaks.
- When inserting a thistle tube into a rubber stopper, do not grasp the thistle tube by the bowl. Always wet the tube and use a twisting motion when applying pressure.
- Keep all bottles labeled at all times. If no other kind of label is available, a piece of adhesive tape will serve the purpose.
- Liquids or solids found in unlabeled bottles should be discarded. Do not guess as to the nature of the substance.
- Bottles containing acids or organic volatile liquids should never be placed near heating pipes nor allowed to stand in the sun; dangerous gas pressures may build up.
- Never cork a bottle containing dry ice or a liquified gas; always plug loosely with cotton.
- Alcohol or other volatile liquids should not be used in a room without adequate ventilation where there is a flame or if a flame may be used shortly thereafter. Rags or cotton swabs soaked in any of these substances should be carefully disposed of in fireproof receptacles.
- Glass wool and steel wool should be handled carefully to avoid getting splinters in the skin.
- The practice of removing thermometers and glass tubing from rubber stoppers as soon as possible after use may prevent the possibility of the glass "freezing" to the rubber.
- Sharp edges on mirrors, prisms or glass plates should be reported by pupils to teacher in charge. Raw glass plates should be bound with adhesive or scotch tape. Waxing edges or plates with melted paraffin is highly effective.

Listed below are some safety rules for handling electrical devices:

- Pupils should be taught never to grasp any electrical device which has just been used. Most electrical devices are hot after use, and serious burns may result if the degree of heat is not ascertained before the device is grasped.
- Pupils should be instructed never to short-circuit dry cells or storage batteries. High temperatures developed in the connecting wires can cause serious burns.

- Students should be cautioned about the danger of shock from the secondary of an induction coil.
- When removing an electrical plug from its socket, pull the plug, not the electric cord.
- When inserting an electric plug, hold the plug so that any flashbacks due to a short circuit will not burn the palm of the hand. This also applies to holding a soldering iron.
- Electrical extensions used in the classroom for projection machines, etc., should be inspected regularly for defects in insulation or connections.
- If there is current in constant use in any metal object, the object should be permanently protected with an insulating cover to avoid possible contact. General care should be observed to see that live wires do not contact grounded metallic objects.
- Care should be observed in teacher and pupil handling of a storage battery. It is a source of danger, in spite of its low voltage, because of the very high current which may be drawn from it on a short circuit.

For plants and animals, the following rules apply:

- Rats, mice, guinea pigs and other laboratory animals should be handled gently by students in order not to unduly excite the animals into biting. Thick rubber gloves should be available and used whenever necessary, that is, when there is danger of being bitten (by excited or feeding animals, new additions to cage, pregnant or feeding females, etc.). Students should be cautioned not to insert fingers in wire mesh or cage. Only specially trained members of the laboratory squad should be permitted to handle laboratory animals. Poisonous snakes should not be kept in the laboratory.
- In handling flowers and bread mold, care should be taken that pollen or spores are not excessivelly distributed through the classroom. Some students may be allergic to them.

Appendix I of *A Guide to Curriculum Development in Science* lists a number of documents with information on safety in the laboratory. Appendix J provides an example of a safety rule sheet for chemistry laboratories at the high school level. All students have to read these rules and sign the sheet as indicated. This sheet can be modified for use in biology, physics, earth science and junior and elementary laboratory situations.

Precautions for field trips

- Pupils should be instructed about identification of poison ivy, poison sumac, and local poisonous snakes.
- First-aid kits should be taken on all field trips.
- Students should be instructed about the proper clothing for a field trip in order to avoid illnesses due to undue exposure.

School policy should insist that, when an accident—no matter how small—occurs, it be reported to the teacher or field trip guide and upon return from the trip, to the nurse or school principal.

Teachers or staff who administer emergency treatment are protected from civil damages for ordinary negligence if they have satisfactorily completed a course in first aid with the American Red Cross, the American Heart Association, the State Department of Health or a municipal health department. (For further detail on this question see Department of Education Circular Letter C-19, December 12, 1977.)

Safety is a team effort

Everyone in the building—administrators, staff, supervisors and students—has a role to play to keep educational programs safe.

Administrators, in cooperation with members of the science department, should make certain that the laboratory facilities and equipment meet state and local requirements. Elementary administrators should have the science supervisors or chairman of the science department from the secondary school study their programs and facilities to insure that they are meeting all safety requirements.

Administrators should design and implement a formal safety program for their systems and individual buildings. They should provide communication to the appropriate town officials of the need for new or improved facilities, equipment, and procedures which will foster a safe science program.

Science supervisors and department heads should develop and detail all aspects of a safe science program and implement this program. Their role is to inform all teachers of new procedures and regulations, provide training to new teachers and elementary teachers in the area of safety. They should inspect laboratory and storage facilities to assure adherence to established guidelines and regulations. The science supervisors should evaluate the program constantly to determine which aspects of the safety program are effective and which have to be changed.

Responsibility of teachers

The teacher of science, be it on the high school, junior high, or elementary level, has the direct responsibility of implementing the safety program in her/his classroom. The teacher must inform the students of any particular danger which may be associated with any experiment the class is conducting. This is an ongoing responsibility and extends beyond the school building or laboratory, especially in cases where science projects are assigned as out-of-school projects.

These safety guidelines for science programs are by no means all inclusive, but serve as an introduction to the topic. Any good safety program will involve a knowledge of federal, state and local laws and regulations as well as the expertise of the teacher in his/her area. Utilizing the knowledge to the fullest will minimize the possibility of accidents in the district's science program.

State and federal agencies

Personnel from the State Department of Education and the unit in the State Department of Labor that administers the federal Occupational Safety and Health Act (OSHA) can assist in promoting safety in the school laboratory. They have technical expertise ranging from specifics on the fire laws to monitoring classrooms for excessive mercury in the air.

8 Instructional Materials

There is a tremendous wealth of science instructional material available today. A major concern for teachers of science is the selection and effective use of these materials for the programs or courses being taught. Textbooks and other instructional materials play a significant role in what teachers teach and in what children learn. It is important that materials be selected with care.

Textbooks

While many schools have written curriculum guides in most subject matter areas, the textbook, to a large extent, determines the curriculum and the instructional patterns used. Since the late 1950s and 1960s, science curriculum projects sponsored by the National Science Foundation in elementary and middle school science and in earth science, biology, chemistry and physics have greatly influenced the textbooks written by other authors and groups. These national projects updated textbook material, reinforced the importance of the inquiry method of teaching, and emphasized both process and content. The subject matter became less descriptive and more concept oriented. In addition much supplementary material, such as films, laboratory programs, additional readings, and other materials were made available. In each of the major science subject matter areas there are many different textbooks available. Most of these books have been revised or new editions published over the last few years. A similar situation exists for elementary and junior high school texts. Because of its importance for the science program, textbook selection is a crucial activity. Teachers, science supervisors and administrators are usually involved in textbook selection. However, teachers should have a major role in textbook selection, since it is they who will use them.

Suggestions for textbook selection

Since a textbook is used for approximately five years, its selection should be made with great care. At the secondary school level, an objective analysis of the text or texts should be made by a committee composed of science department members and other concerned persons such as administrators and curriculum experts. At the elementary school level as many teachers as possible, from all grades in the case of a textbook series, should be involved in textbook selection. An evaluation checklist is helpful to focus on important aspects of a textbook. The textbook evaluation device found in Appendix G contains some of the important criteria. This checklist should be used as a guide only and should be modified to serve the specific needs of the program. If, for example, laboratory activities have a high priority in the school, the rating form should be modified to give greater weight to the lab program and perhaps less emphasis on appearance, illustrations or organization.

It is probably true that no single textbook can meet all the requirements of a school system. Therefore, the selection of supplementary texts, laboratory materials and other correlated hardware and software should also be considered. The order of topics, the depth or breadth of the material covered, the extent of laboratory work and the availability of supplementary materials are some of the variables involved. Students' needs, interests, and teacher expertise are also variables which play a role in the instructional materials to be acquired.

Laboratory equipment

In the elementary school program in science, simple apparatus is to be expected. Much of this equipment is put in containers or packages which hold equipment in classroom quantities for a particular experiment. In the middle school, junior high school and high school, as the experiments become more quantitative, the laboratory experiences require equipment which tends to be more sophisticated. Graduated cylinders, centigram balances, pipettes, burettes, electrical measuring instruments, meters and gauges become more prominent. Much of this equipment is fairly expensive and has a limited life. Long-range planning in consultation with the administrators is necessary so that budgets retain the flexibility to replace broken or obsolete equipment.

Connecticut school populations have declined significantly in the past eight years. At the same time inflation has caused major increases in the costs of textbooks, science supplies and equipment. These increases have outpaced the declining enrollment and it becomes more and more difficult to maintain laboratory programs. A serious commitment to a high level of excellence in science instruction is necessary if we are to survive in our present—and future—high technology society. A well-functioning, well-planned science program has the best chance of keeping the funding abreast of the inflationary changes that are occurring.

Media hardware and software

In addition to the specialized equipment needed in the individual science courses, the science staff should also look to the numerous supplementary teaching aids available today. Hardware should include 8 and 16 mm projectors for films, filmstrip projectors, opaque projectors, and overhead projectors. Other equipment such as videotape recorders, audiotape recorders, microprojectors, microviewers, and microscopes are appropriate to consider for purchase. The software available for science courses today is extensive. Most of the items are well done but they should be previewed. Offers for preview are made by most companies. Models, slides, overhead transparencies, film loops, filmstrips, and audiocassettes are available in most science subject areas. The teacher may consider making his/her own visual materials as well. These teacher-made resources are usually better adapted to the course and the expense is obviously much less.

Calculators and computers

The sharp reduction in the cost of calculators has made them available to the vast majority of students. In developing the local curriculum guide there should be an indication of how and where the calculator can be used. For example, in working with general gas law in chemistry, the concept is often obscured by computations which become tedious. The calculator can be helpful in reducing the arithmetic work so that the relationship may better be seen.

With the advent of the low-cost microcomputers, these devices are becoming more commonplace in the schools. The microcomputer can be used in just about all areas of the school curriculum. The science department probably has at least as many applications for the microcomputer as do other subject areas. Mathematics departments are teaching the use of the microcomputers as a part of the mathematics curriculum. A logical extension of these courses is the application of the computer to science problems and simulations. Some students have their own microcomputers at home. These students can be very helpful in assisting others in the use of this valuable teaching tool.

It is important that science teachers become trained in the use of the microcomputer. This requires a commitment on the part of the science teacher to spend time at the keyboard and by actual use to learn the capability of the computer. Consider in-service training programs which allow credit for such courses. Also, local universities are often willing to tailor a course to the specific needs of a group. They also have the necessary microcomputers to allow for a practical course.

There is little doubt that the computer will play a very significant role in our society in the future. Science and mathematics teachers, in particular, have a major role in orienting students to the computer's use. A decade ago the handheld calculator was at the same stage of development and usage as the microcomputer is at today. Further technological advances and reduced prices undoubtedly will make the microcomputer available to many students outside the classroom. Teachers of those students must be ready to capitalize on the access they have to computers.

Time and again it has been said that a general education must prepare students for jobs many of which do not now exist. Whatever the future, it now appears quite certain that computers will be an important tool for learning, as well as for use in many occupations.

Science Programs and the Community 9

Field trips are remembered by students long after the purposes of the field trips are forgotten. Merely reading and talking about a bird sanctuary is unlikely to bring out the full meaning of the topic as well as an on-site visit.

The field trip has the advantage of fostering better comprehension of concepts and lending realism to the subject being studied. Since places and some processes cannot be brought into the classroom or laboratory, the class must go to them.

Field trips

One must remember that the fundamental objective of the field trip is to clarify or extend major concepts being studied. This is true if the trip is to the school's playing fields, the school's fuse or circuit box or to a site 150 miles away. A visit outside the classroom planned by the teacher, or by the teacher and students, allows the student to use the community as a learning laboratory. The students can explore and make observations; they can look, listen, smell and touch and, if appropriate, taste; they are able to collect information by taking notes, gathering live samples, taking snapshots and interviewing different people. Upon returning to the classroom they can re-examine their collected data. They can compare, test, classify and organize their materials, or just discuss some of their findings. Based on the data collected, they can draw conclusions and possibly extend their experiences into new activities. A list of field trip sites appears in Appendix K.

Caution is needed in choosing trips. Teachers should only plan excursions for their students if the visit can clarify a concept or lesson more adequately than can other learning experiences. Before taking a trip, compare its values with those of alternative experiences in order to decide which type of experience is superior. Filmstrips, films, videotape recordings, lectures, books, tape-recorded interviews, and group telephone calls can be highly effective—used alone, in various combinations, or as supplements to field trips.

Successful field trips do not happen; they are planned. Detailed planning is necessary to insure the trip's success as a learning activity. Poor preparation may result in a slip-up that could cause the trip to fail in meeting its aims. Planning may consume almost as much time as the field trip itself, but it is well worth the effort.

Any trip taken off the school grounds must be justifiable in terms of distance, time, cost and effort. Educational efficiency is an important consideration in the planning of the trip. One example of disregard for this criterion is the transportation of one class to visit a dairy-bottling plant about one and one-half driving hours away from the school, for a 40-minute visit, and then another one and one-half hour trip home.

If at all possible, the teacher or persons planning the trip should previsit the site for several reasons:

- to be able to justify the trip and its potential as a learning experience;
- to become familiar with the route and the place to be visited, and
- to make sure that the trip is a safe one. If a visit to a factory is to take place, what are the hazards of which the students should be aware?

Other information, such as the location of eating sites and comfort stations, opening and closing hours of the site, fees, tour guides and the length of travel time can be collected during this preliminary visit.

All field trips require administrative approval. Early approval will allow time for arranging necessary details.

The school must obtain the written approval of parents. For each trip, the parent or guardian should sign a typed statement granting permission. These statements should be kept on file for at least two months after the trip is taken. A counter-signature of the principal in addition to the teacher's signature assures the parents of administrative approval (see Appendix L).

Consultants and speakers

In every community one can find individuals with expertise in an appropriate area who are willing to share it with students.

A lesson or topic may come to life when an expert presents a firsthand account of experiences, a working document, a piece of equipment, slides, or a technique that is used in the expert's profession or field of interest.

Speakers would be used more often if teachers knew where to find them. Schools should establish a central catalog or file of experts who are willing to be called upon occasionally to speak to a class or group of students about a topic of interest to them.

A catalog of these consultants can be established by having the principal or a group of principals send out letters and consultant forms to adult residents in their district explaining that the schools are trying to find individuals willing to give their services. If a recipient is interested, he/she fills in the form, indicating the area of knowledge and the approximate age group which would benefit from a talk.

It is a good idea for someone to be designated to serve as curator of the catalog and to see that it is kept up-to-date. The school librarian, career coordinator, counselor or an interested parent could serve in this capacity. The catalog may be arranged alphabetically by occupation (author, engineer, nurse, town official, etc.) or by subject (American Indians, biology of birds, ecology, space travel, etc.)

If a speaker is asked to visit the class, the teacher should discuss such matters as the allotted time for the presentation, the specific topics about which the class seeks information, the ability of the class, and the format for the session. Of course, all of this must be done before the speaker arrives at the school.

Personal interviews

There are times when a desired speaker is unable to visit the school, or feels it would be more meaningful if one or two students were to visit her/his place of work. This technique provides students with the personal responsibility for arranging and conducting the interview as well as reporting to the rest of the class.

Listed below are some guidelines for conducting a personal interview.

- Before the interview, build up a background in the content.
- Focus on the specific topic to be investigated.
- Write down specific, open-ended questions that will treat the topic thoroughly.
- Select a resource person and set up an interview time (with an alternate date "just in case") at the person's convenience.
- Send the person being interviewed a copy of the questions to be asked at least one week before the interview so he/she will be prepared.
- Plan a way to open and close the interview.
- Learn how to listen. (This is very important even if permission is granted to tape-record the session.) If a reply is not clear, ask for clarification. Be aware of cues for drawing the interview to a close. Remember to thank the person interviewed, and follow up with a thank-you letter.
- Notes should be organized (edit the tape) for the report for the class. The report should be illustrated with pictures, graphs, models, charts, maps or other audiovisual aids.

A good interview requires an understanding and application of the techniques mentioned above.

Museums and planetariums

Teachers at all levels of instruction should explore the museums within a reasonable radius of their schools in search of exhibits that may focus on some of the topics the class will be studying during the year. Counselors or career coordinators may be of assistance in this process.

Most communities have museums which may offer visits and research opportunities. The "yellow pages" can furnish names of nearby museums. Curators are pleased to have class groups visit.

Astronomy has become an important scientific field of interest. There are a number of planetariums in Connecticut which offer not only programs in astronomy but in related fields as well. The National Aeronautics and Space Administration (NASA) has exhibitions or presentations which often are offered at museums and planetariums. A list of planetariums in Connecticut appears in Appendix M.

The public library

Many public libraries can supply teachers and students with a variety of educational materials. Some of these materials include mounted pictures, recordings on tape and disc, films, filmstrips, slides, newspapers, pamphlets, magazines, atlases and other reference sources.

All teachers should encourage their students to apply for library cards and to begin the habit of using the library for reference reading in connection with their school work.

Internships in business and industry

Many industries, the town government, and places of business in the community are willing to work with teachers and students to enrich science classes. Some of these agencies are willing to offer internships to interested and able students. However, before this can take place the school has to make the initial contact with these agencies to discover what opportunities exist for its students. Also, there are many different types of scientists who are willing and able to work with high school students. Remember that "internship" or "shadowing" programs are different from work-study programs. Internships do not involve funds. The selected student is provided with an opportunity to work with a professional in the student's field of interest. The school makes the initial contact and provides, if necessary, the released time for the students to work in the selected facility. Students assume the responsibility for getting to and from the plant, office or laboratory as well as all other necessary details.

Many benefits accrue from this program. One of these is the contact the school has with the local community. Another is the information the student gains about careers he/she would never obtain were it not for this program.

Cooperative work-study programs

Cooperative work-study programs are based upon individual needs. A cooperative arrangement between school and employer to provide on-the-job experiences is developed to meet these needs. Based upon each student's abilities, there are various levels of programs. The success of these programs rests primarily upon the certified guidance persons running them.

The largest group of youngsters is led into as diverse a range of activities as the community can offer. They develop a worthwhile value system, examine attitudes so that they gain personal strengths and enhance their understanding of society.

The brightest youngsters can benefit through internships or work-study programs at colleges, hospitals and industries. Many of these activities can challenge their abilities.

The potential range of offerings is enormous. A large amount of literature, available from the Bureau of Vocational Services, State Department of Education, should be perused prior to evaluating a work-study program.

Nature and science centers

The Connecticut Association for Environmental Education is a network of nature centers dedicated both to the preservation and improvement of our environment and to the education of our students. Teachers, students and the general public are welcome to enjoy and utilize nature center facilities. The yellow pages of the phone book provide the names of local nature centers. A listing of some of these appears in Appendix K.

An outstanding science center in Avon is the Talcott Mountain Science Center for Student Involvement Inc. Its unique facilities on the top of Talcott Mountain are among the nation's best and must be seen to be fully appreciated.

A marine education program at Avery Point in Groton (Project Oceanology) offers many useful marine activities for students and teachers. Through this project, marine education guides for use in science programs have been made available throughout this region.

Science clubs

Science clubs are an effective means of involving students in direct science experiences. Specific activities within each discipline satisfy the students' curiosity and can provide great satisfaction. Clubs devoted to radio, microcomputer, astronomy, tropical fish, and other interests, seem to be more attractive than general science clubs.

The teacher should not assume the offices and responsibilities. The students should take over the clubs as soon as possible, leaving the teacher as mentor.

Successful science club activities often include the parent or guardian. These activities, held during nonschool hours, often serve to enhance the relationship between adult and child.

State agency resources

Within the State Department of Education, a consultant for each subject discipline is ready and able to respond to inquiries. Each school has the full listing of names, addresses and telephone numbers.

In order to find the numerous other state agencies which may be of assistance to educators, such as the State Department of Environmental Protection, the State Health Department, and Office of Policy and Management's Energy Division, examine the Connecticut *Register and Manual.* This book may be found in schools and libraries.

State and national events

Many state and national programs are available for students of science. Their activities, such as science fairs or academic competitions, allow the student to pursue his or her science interests beyond the classroom. A listing of some of these programs appears in Appendix N.

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Evaluation of the Science Program

Evaluation involves selection, collection and interpretation of information to aid in making decisions about each student's understanding of the processes of science and the subject matter and about the student's competence, scientific attitudes and laboratory skills as well as his/her ability and willingness to work and learn. The total process includes the evaluation of the instructional process as well as the learning outcomes. While this chapter concerns itself primarily with the evaluation of student learning outcomes there is reference to program evaluation as well. Among other references, the National Science Teachers Association's (NSTA) publication *Guidelines for the Assessment of Secondary School Science Programs* addresses the evaluation of facilities, staff and programs.

Evaluation and objectives

Evaluation of learning outcomes begins with the establishment of broad goals which the state, district, and school indicate should be achieved. Implementation of these goals means developing program objectives which state what the learner should know and do as a result of participation in the program. As indicated in Chapter 2, objectives can be stated in terms which specify what is to be achieved, by whom, and under what conditions. They can also include a minimal acceptable level of learner performance. Stating objectives clearly makes it easier to devise or select ways to measure their attainment. To the extent possible, care should be taken to insure that objectives from all levels of the cognitive, affective and psychomotor domains are included in the evaluation procedures.

Science teachers need to employ both qualitative and quantitative procedures for describing and measuring learning outcomes. Some qualitative data collection techniques are behavior and anecdotal records. These techniques are labeled "subjective" because they rely heavily on the interpretation of the individual. Sometimes they are the only feasible way of collecting certain kinds of data. However, their ultimate value may be somewhat limited by relatively low validity and reliability.

Testing Instruments

Most evaluations will utilize some forms of quantitative measurements. The most commonly used testing instruments are teacher-developed tests which may be either the laboratory "practical" or paper and pencil tests. The first rule of test construction is to use student objectives as a guide in making the test. Often, the test is arranged in ascending order of difficulty with similar types of test questions grouped together. There should be questions addressing the various levels of cognitive development. If the stated objectives also indicate a performance standard such as "students will achieve a grade of 80 percent," then the test can be used for criterion-reference purposes. Because they are designed to measure specific program objectives, criterion-referenced tests can also be very useful to the evaluator in determining the success of a program. School districts may want to make use of the competencies in science objectives, presented in Chapter 4 of this document, as a guide in developing their own criterion-referenced tests.

Textbook tests

Many of the program and textbook publishers supply test books which are coordinated with their materials. However, there may be a discrepancy between local program objectives and the test items. More recently, publishers have turned to a "resource book" containing many questions which meet the criteria for the various levels of the cognitive domain and which cover many student objectives. Teachers may then pick and choose those items that best fit the local objectives and thereby construct their own tests.

Standardized tests

There are many standardized tests which have well developed statistics for validity and reliability and which test for everything from general academic achievement to aptitude for a subject area and specific subject knowledge.

Standardized tests are designed to have the scores spread out over a wide range so that the examinees can be compared against each other. Usually standardized achievement tests are not used to show success for a program because the test does not match the specific objectives of the program. Norm-referenced tests are useful for comparing people against each other, but they are not as useful in measuring the achievement of program objectives as are criterion-referenced instruments.

Connecticut Science Assessment

The State of Connecticut as a part of its Connecticut Assessment of Educational Progress has a Science Assessment Program. This test is an adaptation of the National Assessment of Educational Progress science section which is periodically administered in selected schools across the nation. The first Connecticut science assessment was conducted in 1974-75 and the second in 1979-80.

The Connecticut and national assessments have two major goals: to make available comprehensive data on the science education attainments of students at ages 9, 13 and 17, and to measure any growth or decline which takes place in science educational attainments at ages 9, 13 and 17.

Test items are included to gather data about the knowledge, skills and attitudes of students at the specified ages. Data are reported on both the state and national test by specific test items. Local communities using the Connecticut Science Assessment will have available data comparing their students with students in Connecticut, the Northeast and the nation.

Self-assessment

Another form of evaluation, which is probably not used to the extent that it could be, is the self-assessment instrument. Such an instrument enables students to rate their progress toward achievement of the objectives in a course, a unit, or a daily lesson. The instrument consists of a listing of the performance objectives and a choice of rated responses from low to high achievement. This form of evaluation can also be used to show growth as a result of studying the unit by having students complete the form before and after the study.

Generally testing and evaluation are thought of as a means of arriving at a grade for the lesson, unit or course. One should not lose sight of the other interpretations which can be given to test results. If there is a significant difference between a student's score and the teacher's perception of her/his ability, time should be spent to diagnose the cause. If many students miss items which seemed to have been well covered, then time should be spent to examine the teaching methodology and the suitability of the teaching materials. Testing and evaluation should be an ongoing process that is one segment of the total learning experience. A listing of test and evaluation sources appears in Appendix O.

Staff Development

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Science is a dynamic, self-correcting, and constantly expanding enterprise. This means, of course, that teachers of science need to keep abreast of new developments and science curriculum materials need to be continually updated. The knowledge explosion and the tremendous rate of change in many scientific fields means that both teachers and science curriculum materials can be seriously outmoded in a relatively short time unless there is a definite and ongoing program for staff development and curriculum revision. In this regard, teachers of science need assistance in remaining up-to-date in at least three basic areas:

- new developments in the natural sciences, particularly in the area(s) they teach
- new science curriculum projects and science teaching materials
- new and/or alternative methods of teaching

Local staff development

There are a number of things that can be done at the local level to help maintain a steady program of personal and professional growth. For example, self-study and self-improvement can be encouraged by providing teachers easy access to audio and video recording equipment. This will enable teachers to record and preserve sample lessons for later study and analysis. In a similar way, teachers can be encouraged to team up with one or more colleagues and take turns visiting one another's classrooms. Teachers who cooperate in this way are then able to exchange valuable information and informal feedback about classroom interactions. In addition, such classroom visits by fellow staff members can be an important way for each teacher to observe and study other exemplars or models of teaching. Many teachers work alone and seldom, if ever, see colleagues in action in a classroom setting. It seems truly unfortunate that such an inexpensive and simple approach to staff development—informal classroom visits by classroom teachers—is not used by more school systems.

Many teachers have never received any formal training in how to study their own teaching behavior. Most teachers spend years to acquire mastery of their subject matter but often have devoted little or no formal study to their actual performance—verbal and nonverbal behavior—in the classroom. Thus, there may be great potential gain for local systems to encourage teachers to engage in efforts to learn more about the art of teaching. In recent years, a number of systems have been devised that can be used by teachers to study and analyze their own teaching behavior.

Among the many systems now available, Flander's Interaction Analysis and Parson's Guided Self-Analysis are two very useful and easily learned systems that can be used by individual teachers or small teams to study and improve their teaching. Thus, by providing time and the appropriate study materials, local school systems can be very helpful and influential in this sphere of staff development.

In-service sessions can be another avenue to staff development, and these usually take the form of mini-courses or single-topic workshops dealing with new developments in science and science curriculum and taught by a local supervisor, special resource teacher or person from a nearby college. Each school system should take care not to overlook other potentially valuable local resources for staff development and curriculum enrichment such as amateur and hobby organization (e.g., astronomy club), health organizations (e.g., American Red Cross), local industries (e.g., American Cyanamid), government agencies (e.g. the United States Submarine Base in New London), and local historical societies.

Another fairly simple and direct way of encouraging and supporting staff development is to provide easy access to resource materials. Professional and scientific books and journals can be of assistance to teachers interested in acquiring innovative and up-to-date materials and techniques. There are many helpful resource materials and new ones are published every year. Thus, each school system should allocate budgetary funds on an annual basis for the acquisition of new books and for journal and magazine subscriptions. Appendix P contains a listing of resource materials. These represent a sampling of the books and journals that can be housed in a departmental or school library.

Regional staff development

Regional resources for staff development are usually more varied and extensive than those available locally, but also require more cooperation, coordination and planning.

Here again, a basic first step may be to encourage teachers to visit their counterparts in nearby towns. Released time granted for such visits—two or three times a year—should improve inter-school communication and sharing and make it unnecessary for each school to reinvent the wheel. There are many educational resources within driving distance of virtually all school systems. Personnel from school systems should look into these resources when considering possibilities for credit and noncredit courses to train, retrain, or update their teachers. The staff at a zoo, for example, might agree to offer a mini-course designed to give teachers information about the natural history of vertebrates, the behavior of animals in captivity, and the care and treatment of small native animals. Likely resources that might assist school systems by offering workshops for teachers include the following:

Resources	**Topics for Teacher Workshops**
Aquariums	Setting up Aquarium Tanks Underwater Photography Marine Science
Agricultural Experiment	Plant Pollination Incubating Baby Chicks Hydroponic Procedures
4-H Extension Centers	Tree Identification Raising Small Farm Animals Nutrition, Food Preparation and Preservation
Historical Societies	Connecticut Inventors Great Moments in Connecticut Science and Technology
Nature Centers	Ecology and Natural History Sidewalk (urban) Ecology
Science Museums	Evolution of Dinosaurs Endangered Species Fossil Man
Planetariums	Celestial Navigation New Knowledge of the Solar System Stellar Evolution
Zoos	Humane Treatment of Small Native Animals and Pets Animal Communication Learning and Conditioning Techniques

A number of state agencies might also be able to help with science staff development by supplying materials, workshops, or opportunities for summer internships. Thus, school systems should not overlook potential assistance from such state agencies as the Geological and Natural History Survey, Department of Environmental Protection, fish hatcheries, and tree farms.

Higher education

Connecticut is dotted with many institutions of higher learning, many of which have a long tradition of helping preservice and in-service teachers. The state-supported institutions include the University of Connecticut and its branch campuses, the four state colleges (formerly teachers' colleges), the 12 community colleges, and the five technical colleges. The private colleges and universities in

Connecticut provide another major resource. All of these institutions can help teachers in various ways, including formal courses, dissemination sessions, and independent study opportunities.

Educational service centers

Connecticut's Regional Educational Service Centers (RESC) are probably the most responsive and flexible of all the resources available to local school districts. These centers are capable of bringing together a wide variety of human, natural and technological resources to meet specific needs at specific times in special (often local) situations. Teachers can turn to these centers for print and nonprint materials, literature searches, curriculum materials, and a variety of in-service workshop sessions. See Appendix Q for addresses of the six centers in Connecticut.

Professional associations

One of the best ways of obtaining information and staff development experiences about recent happenings in science education is through science teachers associations.

The National Science Teachers Association publishes a number of journals, newsletters, monographs and position statements which may be helpful.

The Connecticut Science Teachers Association (CSTA) publishes a very informative newsletter which appears about six to eight times a year and an impressive journal which is published two or three times per year. CSTA also provides at least one major meeting and several regional meetings each year. These events bring together college and public school people who make presentations in their areas of expertise. Vendors of commercial science instructional materials exhibit their wares. These meetings are a worthwhile and effective way for teachers to update their knowledge of the present state of the art.

The Connecticut Science Supervisors Association was formed recently to address the concerns of science department heads. Attendance at its meetings, however, is open to all interested parties. The Association holds meetings about four times a year.

Each subject matter discipline has an association (National Association of Biology Teachers, New England Association of Chemistry Teachers, American Association of Physics Teachers) dealing with concerns specific to that discipline. Teachers should be encouraged to join and become involved with these and the other more general science associations such as the National Science Teachers Association. In this way teachers will be better able to remain abreast of the many changes taking place in the field.

Appendix A
Statewide Goals for Education

From Connecticut's *Comprehensive Plan for Elementary and Secondary Education, 1980–1985*

GOAL ONE

Motivation to Learn

To realize their potential to learn, students must be highly motivated.

Therefore:

Connecticut public school students will develop strong motivation by responding to the high expectations of their parents, teachers and school administrators; by understanding and striving to fulfill personal aspirations, and by developing the positive feelings of self worth which contribute to responsible behavior and personal growth, health and safety.

GOAL TWO

Mastery of the Basic Skills

Proficiency in the basic skills is essential for acquiring knowledge and for success in our society.

Therefore:

Connecticut public school students will, to their full potential, learn to communicate effectively in speech and writing; read with understanding; acquire knowledge of and ability in mathematics, and strengthen decision-making skills.

Appendix A (continued)

GOAL THREE

Acquisition of Knowledge

Acquiring knowledge leads to fuller realization of individual potential and contributes to responsible citizenship.

Therefore:

Connecticut public school students will acquire the knowledge of science, mathematics, social studies, the arts, literature and languages which leads to an understanding and appreciation of the values and the intellectual and artistic achievements of their culture and other cultures, and will take full advantage of opportunities to explore, develop and express their own uniqueness and creativity.

GOAL FOUR

Competence in Life Skills

Students are challenged to function successfully in multiple roles as citizens, family members, parents, producers and consumers.

Therefore:

Connecticut public school students who complete secondary level studies will have the ability to make informed career choices; understand the responsibilities of family membership and parenthood; be prepared to undertake the responsibilities of citizenship in their communities, in the state, in the nation and in the world; and have the skills, knowledge and competence required for success in meaningful employment, or be qualified to enter postsecondary education.

GOAL FIVE

Understanding Society's Values

To be responsible citizens and contribute to positive change, students must understand and respect the underlying values of this society.

Therefore:

Connecticut public school students will appreciate diversity and understand the inherent strengths in a pluralistic society; they will understand and respond to the vital need for order under law; they will acquire the knowledge necessary to live in harmony with the environment, and actively practice conservation of natural resources, and they will respect the humanity they share with other people.

Appendix B
Legislation

The series of guides to curriculum development published in 1981 by the State of Connecticut Board of Education is consistent with the provisions of Sections 10-4 and 10-16b (or P.A. 79-128) of the Connecticut General Statutes.

Section 10-4. Duties of Board. (a) . . . shall prepare such courses of study and publish such curriculum guides . . . as it determines are necessary to assist school districts to carry out the duties prescribed by law . . . .

Section 10-16b. Prescribed courses of study. (a) In the public schools the program of instruction offered shall include at least the following subject matter, as taught by legally qualified teachers: the arts; career education; consumer education; health and safety; language arts, including reading, writing, grammar, speaking and spelling; mathematics; physical education; science; social studies, including, but not limited to, citizenship, economics, geography, government and history; and in addition, on at least the secondary level, one or more foreign languages and vocational education.

(b) Each local and regional board of education shall on September 1, 1982, and annually thereafter at such time and in such manner as the commissioner of education shall request, attest to the state board of education that such local or regional board of education offers at least the program of instruction required pursuant to this section, and that such program of instruction is planned, ongoing and systematic.

(c) The state board of education shall make available curriculum materials and such other materials as may assist local and regional boards of education in developing instructional programs pursuant to this section.

Appendix C
Curriculum Guides in Science

State Guides

Arizona. State Department of Public Instruction. *Science Guide for Elementary Schools of Arizona.*

California. State Department of Education. *Science Framework for California Public Schools, Kindergarten and Grades One Through Twelve.* Sacramento: 1978.

Indiana. State of Indiana Department of Public Instruction. *Indiana School Science Program K–12.* Indianapolis: 1980.

Iowa. Department of Public Instruction. *A Tool for Assessing and Revising Science Curriculum.* Des Moines: 1980.

Michigan. Department of Public Instruction. *Guidelines for the K–12 Science Program.* Lansing: 1961.

Michigan. Department of Education. *Minimal Performance Objectives for Science Education in Michigan.* Lansing: 1974.

North Carolina. Department of Public Instruction. *The Instructional Leader and the School Science Program.* Raleigh.

Oregon. Department of Education. *Framework for Science Programs.* Salem: 1979.

South Carolina. State Department of Education. *Science Education K–12—Administrator's Planning Guide.* Columbia: 1972.

South Dakota. Department of Education and Cultural Affairs. *South Dakota Framework for Science Curriculum Development K–12.* Pierre: 1980.

Texas. Texas Education Agency. *Science Framework–Kindergarten Through Grade 12.* Austin.

Professional Association Guides

Connecticut Science Teachers Association, Ad Hoc Committee for Science Competencies. Dr. Bette J. DelGiorno, Chairperson. *Procedures for Developing Competencies Documents.* Fall 1977.

Connecticut Science Teachers Association. *Suggested Science Competencies for Students Completing Grades 4, 8, and 12 in Connecticut Schools.* May 1980.

National Science Teachers Association. *Conditions for Good Science Teaching in Secondary Schools.* Washington, DC: 1970.

National Science Teachers Association. *Theory into Action . . . in Science Curriculum.* Washington, DC: 1964.

Commercial

Flanagan, J.C., R.F. Mager and William M. Shanner. *Science Behavioral Objectives—A Guide to Individualized Learning—Primary–Intermediate–Secondary.* Palo Alto, CA: Westinghouse Learning Press.

Performance Objectives Catalog, Science K–6, 7–9. Iowa City, IO: Westinghouse Learning Corporation, P.O. Box 30.

Many vendors of science texts also publish specific objectives for their programs.

Connecticut Local School District Guides

As a part of the 1978 Connecticut Secondary Science Education Survey, science department chairpersons or supervisors were asked whether locally developed curricula or curriculum guides were available to teachers in their district. The list which follows was developed from districts responding to the survey and indicating that such guides were available. Those districts which are asterisked indicated that performance objectives were used in their curricula.

- *Ansonia
- Avon
- *Bolton
- Branford
- *Bristol
- Brooklyn
- Cheshire
- *Clinton
- *Danbury
- *Darien
- *Deep River
- *East Hampton
- *East Hartford
- East Haven
- *East Lyme
- *East Windsor
- Easton
- *Enfield
- *Fairfield
- *Farmington
- Glastonbury
- *Granby
- *Greenwich
- *Guilford
- *Hartford
- *Hebron
- *Killingly
- *Manchester
- *Meriden
- *Middletown
- *New Britain
- New Canaan
- *New Fairfield
- *New Haven
- *Newington
- New London
- *North Haven
- Norwalk
- *Plainfield
- *Plainville
- *Plymouth
- Portland
- *Rocky Hill
- *Somers
- Southington
- *South Windsor
- *Southbury
- *Stafford Springs
- *Stamford
- *Suffield
- Thomaston
- *Vernon
- Vocational-Technical Schools
- *Wallingford
- Waterbury
- *Waterford
- *Watertown
- *West Hartford
- West Haven
- *Weston
- *Westport
- *Wilton
- *Willimantic
- Windsor
- *Windsor Locks

Appendix D
Three-Column Format
Example from "Biology"

The State Education Department
Albany, NY

Unit 2 - Maintenance of Animals

The following statements provide a frame of reference for Unit 2:

- *The animal examples used are treated horizontally with each life function being treated once for each representative organism.*
- *Evolutionary trends evident in comparing each representative are stressed.*
- *Emphasis is placed on the relationship between structure and function.*
- *Chemical concepts are treated descriptively and are introduced at points appropriate to the understanding of biological principles.*

Topics	**Understandings and Fundamental Concepts**	**Supplementary Information**
	The maintenance of animal life is dependent on universal requirements: • obtaining and distributing essential organic and inorganic compounds • removal of metabolic waste products • regulation of processes	
I. Nutrition		
A. Process	Nutrition includes those activities of animals by which they obtain and utilize various substances (known as nutrients or foods) for metabolic activity. Foods or nutrients are substances that serve as:	While nutrition may be extended to include all activities and destinies of consumed materials, only intake and processing of nutrients are treated in this

Topics	Understandings and Fundamental Concepts	Supplementary Information
	• energy sources for various life activities of cells • constituents in the building or repair of cell structures • regulators of metabolic processes	section. The distribution and specific roles of physiological compounds are described in later sections.
	Animals lack the ability to synthesize nutrients from inorganic raw materials and must consume preformed organic compounds. This mode of nutrition is known as heterotrophic nutrition.	
	Usually, other organisms (plants and/or animals) are consumed by animals and serve as a source of preformed nutrients. Food organisms may contain unnecessary or unavailable compounds as well as those with nutritional value.	
1. Ingestion	Ingestion describes those activities of animals by which they take in materials (compounds and/or organisms) which serve as a basis for nutrition.	
2. Digestion	Digestion involves the reduction of large or insoluble food materials to small, soluble molecules which may be distributed throughout an animal and used for various physiological activities.	
	Digestion may occur within cells (intracellular) or outside of cells (extracellular).	
a. Mechanical aspects	Many animals exhibit adaptations which permit the breakdown of food materials to small particles through purely physical means such as grinding, cutting, and tearing.	
b. Chemical aspects	Mechanical digestion reduces food materials to particles which, by molecular standards, are still exceedingly large. Further reduction to soluble form is accomplished through the action of enzymes.	
(1) Enzyme action	Enzymes are proteins which act as catalysts and affect many physiological reactions, including digestion.	Teachers who do not select the BC extension of Unit 1 may wish to examine section C of the BC extension for additional treatment of enzymes.
	Digestive enzymes are hydrolytic. They promote the breakdown of large molecules to small unit molecules with the addition of water.	

Topics | **Understandings and Fundamental Concepts** | **Supplementary Information**

The name of an enzyme is usually formed by adding the ending *-ase* to a stem which is taken from the substrate (compound, or class of compound) upon which the enzyme acts. Some examples of digestive enzymes and their substrates include:

Enzyme	Substrate
maltase	maltose
lipase	lipids
protease	protein

Enzymes are specific in their action. They will usually only catalyze reactions involving a single substrate compound or a group of closely-related compounds.

Temperature and hydrogen-ion concentration (pH) are two of the factors which determine the rate of enzyme action.

(2) Outcome

As a result of the action of enzymes in chemical digestion, complex organic molecules are hydrolyzed to smaller, soluble molecules.

- carbohydrates (sugars, starches, etc.) are converted to simple sugars such as glucose
- proteins are converted to amino acids
- lipids (fats, oils, etc.) are converted to fatty acids and glycerol

B. Adaptations

Nutritional patterns among animals vary in accordance with the adaptations which have evolved to permit the ingestion and digestion of food materials.

1. Protozoa

Protozoa ingest food organisms by taking them in through fixed openings (as in paramecium) or engulfing them (as in amoeba).

Protozoa have no digestive tract. Ingested food materials accumulate in food vacuoles where digestion occurs. Digestion is intracellular.

Although protozoa are classified by many biologists as protists (see Unit VI, section C—A Modern Classification System), they are compared with animals in this section because they exhibit animal-like characteristics and are thought to be descendants of evolutionary precursors to multicellular animals.

Appendix E
Four-Column Format
Example from "General Chemistry"

The State Education Department
Albany, NY

Area 6–Environmental Pollution

Topical Outline	Understandings and Concepts	Laboratory Experiences	Supplementary Information
I. Introduction	A pollutant is a substance found in the environment which normally is lacking, or, if naturally occurring, is found in greater than normal concentrations.		
	Pollutants may be natural or man-made.		Natural pollutants include pollen, dust, silt, and microbes. Man-made pollutants include sewage, pesticides, industrial wastes, and automotive emissions.
	Contamination of our environment has increased to a point that it is a serious threat to the health and economic welfare of society.		The rate at which man adds pollutants to the environment is so great that some authorities estimate that the total amount of pollution in the world doubles every 10 years.

Appendix E (continued)

Topical Outline	Understandings and Concepts	Laboratory Experiences	Supplementary Information
	In the past, man has depended on dilution and natural purification processes to control pollution.		Man can no longer depend upon natural processes for pollution control.
	Factors which contribute to the increasing contamination of the environment are the population explosion, the growth of industrial processes, the growth of large urban centers close to each other, and the desire for an ever higher standard of living.		
	The first important requirement of a pollution control program is an aroused community of informed citizens and officials.		Discuss the role of the individual and of local, State, and Federal governments in controlling pollution.
			Legislators, lawyers, public health officials, and sanitary engineers are good resource people for class visitations, either in person or via tape.
	Pollutants may be found in water, in air, and/or on land. A particular activity of man may cause pollution in all three areas.		People in their daily living activities add pollutants to the environment when they drive automobiles, heat their homes, discharge sewage, dispose of refuse, etc.
II. Water			
A. Water supply	Man obtains most of		Surface water in-

Topical Outline	Understandings and Concepts	Laboratory Experiences	Supplementary Information
	his water from surface water and ground water.		cludes lakes, rivers, streams, and reservoirs. Ground water is water naturally found beneath the surface of the earth.
	The total amount of water on earth remains relatively constant. Water is continually circulating through a cycle of precipitation, runoff, infiltration, storage, evaporation, and reprecipitation called the water cycle.	A terrarium can be used to illustrate the natural water cycle. If a terrarium is unavailable, a sealed plastic bag containing a little water can be used to show the processes of evaporation and condensation.	The demand for fresh water has been increasing. Some surveys indicate a shortage of fresh water in the future. The population of the United States increased two and one-half times from 1900 to 1960, but the use of water per day increased four times for the general population, seven times for agriculture, and eleven times for industry.
	The water from a major river can be used many times as it flows from the source of the river to its mouth. The only practical solution to a shortage of fresh water is more reuse of the same water.		
	When water from precipitation and "returned" ground water are not added to the water table at the same rate that they are removed, the depth of water in the table decreases and a water shortage may occur.		The lowering of the water table in some parts of the country is a matter of great concern.
B. Naturally occuring substances in the water supply			
1. Rainwater	Naturally occurring substances found in rainwater include fine particles of salt, dust,		Traces of ozone, nitrogen oxides, argon, sulfur dioxide, ammonia, and other

Appendix E (continued)

Topical Outline	Understandings and Concepts	Laboratory Experiences	Supplementary Information
	and smoke which served as condensation nuclei. The principal gases from the air dissolved in rainwater are oxygen, nitrogen, and carbon dioxide.		gases may be present in rainwater.
	Most rainwater is weakly acidic because of the carbon dioxide dissolved in it.	Test the pH of rainwater.	The pH value of rainwater ranges from 5.5 to 6.0.
2. Ground water	When weakly acidic rainwater falls upon the earth, more carbon dioxide is taken up as the water infiltrates the soil, flows in streams, and/or is stored. Substances that dissolve in weak acids are leached by the ground water. This reduces the acidity and increases the concentration of minerals in the water.	Test the pH of ground water.	Ground water containing weak alkaline materials may have a pH range of 8.0 to 8.5.
	Water containing ions of calcium, magnesium, and/or iron is called hard water.	Compare the number of drops of "standard" soap solution needed to produce suds in samples of water from different sources.	The number of drops of standard soap solution necessary to produce suds is a rough measure of the degree of hardness in water.
	Hard water renders soap ineffective as a cleaning agent.	Soap solutions can be "standardized" by comparing the number of drops needed to produce suds in distilled water.	*Students may encounter the unit parts per million (p.p.m.). The unit is used to express small concentrations of substances in water without using fractions.*

Topical Outline	Understandings and Concepts	Laboratory Experiences	Supplementary Information
		Evaporate water from different sources and compare the amount of residue. Ignite the residues. Inorganic residues will not char. Organic residues will char.	*1.0 p.p.m. = 1 mg./liter* *1 liter water = 1,000,000 mg. water* *1 p.p.m. = 1 mg./1,000,000 mg. water*
		Demonstrate that the ability to conduct electricity is a way of measuring the concentration of dissolved minerals.	
C. Water pollutants			
1. Sewage	Sewage is water carrying human, animal, or organic wastes from homes, industrial establishments, or other places.		Fresh sewage is a turbid liquid containing organic and and inorganic "solids" which may be dissolved, suspended, or floating.
	Sewage contains human and animal body discharges, household wastes, street washings, ground water, infiltration, and industrial wastes.	A 6.01 may be used to detect oil in street washings.	Organic solids include animal and plant waste products, dead animal matter, plant tissue, and synthetic organic materials such as soaps, detergents, frothing agents, and grease.
			Inorganic matter in sewage includes sand, grit, gravel, silt, and mineral salts.
	Bacterial action causes the decomposition of organic matter.		The bacteria may use organic matter for food and decompose it into simpler substances.

Appendix F
Special Science Offerings* in Connecticut Schools

- Advanced Biology (not A.P.)
- Advanced Chemistry
- Advanced Physics
- Advanced Placement Biology
- Advanced Placement Chemistry
- Advanced Placement Physics
- Aeronautics
- Allied Health
- Applied Science
- Astronomy
- Botany
- Chemistry for Health Science
- Comparative Anatomy
- Contemporary Science
- Drug Awareness
- Ecology
- Electronics
- Embryology
- Environmental Education
- Field Natural History
- Geology
- Horticulture
- Independent Study
- Invertebrate Zoology
- Laboratory Safety
- Laboratory Technology
- Mammalogy
- Marine Biology
- Meteorology
- Microbiology
- Mineralogy
- Nurse Assistant
- Oceanography
- Oceanography Field Work
- Ornithology
- Patterns and Processes
- Physical Chemistry
- Physiology
- Plant and Animal Care
- Public Health
- Science in the Home
- Science of Cars
- Science Seminar
- Science Topics
- Unified Science
- University of Conn. Coop Program
  - Chemistry
  - Biology
- Vertebrate Zoology

*Other than earth science, biology, chemistry and physics.

Appendix G
Suggested Criteria for the Selection of Science Texts

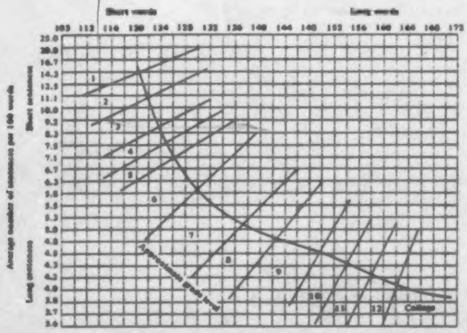
I. Content	**Good**	**Acceptable**	**Poor**
1. Content and instructional approach is consistent with local philosophy, goals and objectives.			
2. Content is appropriate and well balanced, i.e., for elementary schools—earth science, life science, physical science; for earth science— astronomy, geology, meteorology, oceanology.			
3. Content is up-to-date.			
4. Safety is stressed.			
5. The SI metric system is used or included.			
6. Environmental and social implications are included.			
7. Career information is available.			
8. Content is up-to-date and accurate. (Select some facts at random and check.)			
9. Pictures, diagrams, tables and charts are appropriate for level of students.			
II. Authors, Support Staff and Inservice			
1. Authors are authorities in their fields.			
2. Authors have experience teaching the subject(s).			
3. Editorial consultants (if used) are knowledgeable of the specific areas included.			

Appendix G (continued)

	Good	Acceptable	Poor
4. Cooperating teachers (if used) have piloted materials.			
5. Publisher provides in-service by authors or other consultant staff.			
III. Organization			
1. Presents topics in a logical sequence.			
2. Length of chapter, lessons or work are appropriate.			
3. Provision is made for various levels of difficulty in an appropriate order.			
4. References, class tests, summaries are clearly represented and appropriate.			
IV. Readability			
1. Vocabulary is suitable for those who will use the text.			
2. Print is clean and well spaced.			
3. Writing style is direct and clear.			

The Fry Readibility Graph appears below. Developed by Edward Fry at the Rutgers University Reading Center at Rutgers University, the graph appears on page 101 of *Science Framework for California Public Schools—Kindergarten and Grades One Through Twelve*. That volume is not copyrighted and may be reproduced.

Directions: Randomly select three 100-word passages from a book or article. Plot the average number of syllables and the average number of words per sentence on a graph to determine the area of readability level. Choose more passages per book if great variability is observed.*



Graph for estimating readability

*This procedure can be an interesting and useful programming project for a student.

	Good	Acceptable	Poor
V. Ethnic and Sex Representation			
1. Ethnic groups and the sexes are fairly represented in text, pictures, and references.			
VI. Physical Features			
1. Size of book is appropriate for age of student.			
2. Books are durable—cover, binding, pages.			
3. Book is well laid out and attractive.			
4. Adequate table of contents, index, cross referencing, bibliography, resource materials.			
5. Photographs, tables, illustrations, are clear, understandable and recent.			
VII. Teacher Aids			
1. Teacher's edition gives useful information about teaching techniques.			
2. Appropriate films, filmstrips, etc. are listed.			
3. Test questions, problem solutions and text summaries are available and clear.			
VIII. Vendors			
1. Vendors are available to answer questions regarding in-service, initial and continuing costs, provide for in-service, etc.			

Summary.. **Good** ________
Acceptable ________
Poor ________

Recommendation
Purchase ________
Hold for further discussion ________
Reject ________

Appendix H Resources Relating to Exceptional Children

Books and Journals

American Journal of Mental Deficiency. American Association of Mental Deficiency, 5101 Wisconsin Avenue, NW, Washington, DC 20016.

Carin and Sund. *Teaching Science Through Discovery,* 4th edition. Columbus, OH: Charles E. Merrill Publishing Co., 1980.

Education and Training of the Mentally Retarded. Council for Exceptional Children, 1920 Association Drive, Reston, VA 22091.

Exceptional Children. Council for Exceptional Children, 1920 Association Drive, Reston, VA 22091

Exceptional Children in the Regular Classroom. Council for Exceptional Children, 1920 Association Drive, Reston, VA 22091

Education of the Visually Handicapped. Association for the Education of the Visually Handicapped, 919 Walnut Street, 4th Floor, Philadelphia, PA 19107.

Journal of Learning Disabilities. Professional Press Inc., 101 E Ontario Street, Chicago, IL 60611.

Journal of Special Education. Grune and Stratton, Inc., 111 Fifth Avenue, New York, NY 10003.

Journal of Visual Impairment and Blindness. American Foundation for the Blind, 15 West 16th Street, New York, NY 10011.

Science for the Handicapped (Newsletter). Department of Education, University of Wisconsin, Eau Claire, WI 54701.

Teaching Exceptional Children. Council for Exceptional Children, 1920 Association Drive Reston, VA 22091.

The Volta Review. Alexander Graham Bell Association for the Deaf, 3417 Volta Place, NW, Washington, DC 20007.

Publications Dealing With the Gifted Child

Developed and disseminated by the Connecticut State Department of Education.

CONN-CEPT I—Connecticut's Planning for the Gifted and Talented: Practical Suggestions for Gifted and Talented Program Development. William G. Vassar and Sandra K. Krusnick, editors. Connecticut State Department of Education, Fall 1979. 136 pp. (Revised Edition).

CONN-CEPT II—Connecticut's Programming for the Gifted and Talented: Differentiated Curriculum for the Gifted and Talented in Science and Mathematics. D. LaSalle, et al. Connecticut State Department of Education, 1978. 100 pp.

CONN-CEPT III—Connecticut's Programming for the Gifted and Talented: Once Upon A Building. P. Cobb, S. Cobb and C.M.E. Dow. Connecticut State Department of Education, 1978. 100 pp.

CONN-CEPT V—Connecticut's Programming for the Gifted and Talented: Task Force Report on Identification. A. White, editor. Connecticut State Department of Education, 1978. 71 pp. (Revised Edition).

CONN-CEPT VII—Connecticut's Programming for the Gifted and Talented: Task Force Report on Curriculum. A. White, editor. Connecticut State Department of Education, 1978. 100 pp. (Revised Edition).

CONN-CEPT IX—Identifying and Programming for Hispanic Gifted and Talented Students. MIRANDA et al. Connecticut State Department of Education, 1980. 100 pp.

CONN-CEPT X—Differentiated Curriculum in Marine Studies/Computer Science for the Gifted and Talented. Haakonsen and Danielson. 113 pp. plus appendices.

Organizations Which Help Handicapped Learners and Their Teachers

Adapting Science Materials for the Blind (ASMB) and Science Activities for the Visually Impaired (SAVI). Lawrence Hall of Science, University of California—Berkeley, Berkeley, CA 94720.

American Printing House for the Blind, P.O. Box 6085, Louisville, KY 40206.

Alexander Graham Bell Association for the Deaf, 3417 Volta Place, NW, Washington, DC 20007.

Biological Sciences Curriculum Study, P.O. Box 930, Boulder, CO 80302.

Bureau of Education for the Handicapped, Office of Education, 400 Maryland Avenue, SW, Washington, DC 20202.

Chemistry Department, American University, Washington DC 20009.

Council for Exceptional Children, 1920 Association Drive, Reston, VA 22091.

Institute for Research on Exceptional Children, University of Illinois, Urbana, IL 61801.

National Center on Education Media and Materials for the Handicapped, Ohio State University, Columbus, OH 43210.

Society for Crippled Children, 2800 Thirteenth Street, NW, Washington, DC 20009.

Appendix I
Science Safety Guides

Science Educator's Guide	Chapter 6 "Science Laboratory Safety" Connecticut State Department of Education, Hartford, 1975. Available from ERIC Document Reproduction Service, P.O. Box 190 Arlington, VA 22210, ERIC Number ED 114281
Fire Safety and Prevention Manual for Connecticut Public Schools—Guide for Science Chemistry, Biology and Physics Laboratories	Connecticut State Department of Education, P.O. Box 2219, Hartford, CT 06115
Safe School Guide	Connecticut State Department of Education, P.O. Box 2219, Hartford, CT 06115
Safety First	Delaware State Department of Public Instruction, Dover, DE 19901, 1976
Safety First in Science Teaching	North Carolina Department of Public Instruction, Raleigh, NC 27611, 1977
Safety in Handling Hazardous Chemicals	Matheson, Coleman and Bell, 2909 Highland Avenue, Norwood, OH 45212
Science Safety	Department of Education, Commonwealth of Virginia, Richmond, VA 23216, 1976
Laboratory Safety Handbook	Mallinckrodt, Inc., Science Products Division, P.O. Box 5439, St. Louis, MI 63147, 1969
Safety in the Science Laboratory	State Department of Education, Tallahassee, FL, 1968
Guide for Laboratory Animal Facilities and Care	U.S. Department of Health, Education and Welfare, Superintendent of Documents, U.S.

	Government Printing Office, Washington, DC 20402
Resource Unit on Electrical Safety Education for Grades K—12	Curriculum Guide No. 41, Department of Education, St. Paul, MN, 1977
Safety in the Secondary Science Classroom	National Science Teachers Association, 1742 Connecticut Ave., NW, Washington, DC 20009, 1978
Safety in the Elementary Science Classroom	National Science Teachers Association, 1742 Connecticut Ave., NW, Washington, DC 20009, 1979
Fire Protection Guide on Hazardous Materials	National Fire Protection Association, 60 Batterymarch Street, Boston, MA 02110, 1969
Everything You Wanted to Know about Science Safety	Massachusetts Association of Science Supervisors
Science Safety	Division of Secondary Education Department of Education, Commonwealth of Virginia, Richmond, VA 23216
Hazardous Waste Management Facilities in the United States	U.S. Environmental Protection Agency, Washington, DC, 1977
Your Laboratory and the Occupational Safety and Health Act (OSHA)	Fisher Scientific, Co., 4901 W. LeMoyne Ave., Chicago, IL 60651
Safe Storage of Chemicals—A Checklist for Teachers	David A Pipitone, *The Science Teacher,* Volume 48, Number 2, February 1981, pp. 16–21.
Some Suggested Safe Practices in the Storage and Handling of Laboratory Animals	Technical Service Department, Flinn Scientific, Inc., P.O. Box #231, 910 W. Wilson Street, Batavia, IL 60501

Appendix J
Laboratory Safety Rules Form

New Canaan (CT) High School

1. Sandals are not to be worn in the laboratory.
2. Safety glasses are to be worn at all times.
3. Long hair is a hazard and extreme care must be exercised to keep hair from contact with flame or chemicals. (Use rubber bands when necessary!)
4. It is advisable to wear clothing other than your best garb to lab. Long sleeve sweaters, blouses and shirts are not advised. Aprons will be worn when necessary.
5. Use the proper amount of chemical at all times.
6. Do not point the open mouth of a test tube at yourself or at any other person. . . In attempting to detect the odor of any substance, waft the odor toward your nose.
7. Only the lab manual, your notebook, and the experiment materials are to be on the lab bench. Books and all other materials are to be left at your desk or in the bench shelf.
8. All work with chemicals is to be done over the bench top to prevent spills on the floor.
9. Keep all chemicals and reactions at a reasonable distance from your face.
10. Read all labels carefully and do not return any unused portion to the reagent container.
11. The lab tables are not for sitting or lounging. Keep off! Do not move chairs to the lab bench area or sit on the arms of the chairs.
12. Report any accident to the lab instructor immediately in order that proper first aid may be administered.

____

names of laboratory instructors

I have read the Chemistry Laboratory Safety Rules and agree to comply with them. I understand that I will be asked to leave the laboratory should I disregard them.

____________________________ ____________

student signature date

Appendix K
Field Trip Sites in Connecticut

The field trip sites listed in Appendix K, were extracted with permission from three documents. For additional sites, consult these documents.

> Connecticut State Department of Education. *Energy Resources Inventory for Connecticut Educators*. Hartford, CT: 1980.
>
> Connecticut Department of Environmental Protection. *Connecticut Directory of Environmental Organizations*. Hartford, CT: 1980.
>
> Tobin, Michael F., editor. *Field Trip Guidebook*. Hartford, CT: Elementary School Principal's Association of Connecticut, 1979.

For a list of planetariums in Connecticut, see Appendix M.

Air Quality Monitoring Stations, Air Compliance Unit, Department of Environmental Protection, Hartford, CT 06115
American Indian Archeological Institute, Aertis Road, Washington, CT 06793
Audubon Center in Greenwich, 613 Riversville Road, Greenwich, CT 06830
Barnum Museum, 820 Main Street, Bridgeport, CT 06604
Beardsley Zoological Gardens, Noble Avenue, Bridgeport, CT 06110
Bradley Air Museum, Bradley International Airport, Windsor Locks, CT 06096
Bristol Regional Environmental Center, Wolcott Road, Bristol, CT 06010
The Children's Museum, 567 State Street, New Haven, CT 06510
The Children's Museum, 950 Trout Brook Drive, West Hartford, CT 06119
Connecticut Audubon Society, 2325 Burr Street, Fairfield, CT 06430
Connecticut Trout Hatcheries, Burlington, CT 06013; Central Village, CT 06332; Kensington, CT 06037
Connecticut Humane Society, 701 Russell Road, Newington, CT 06111
Connecticut Yankee Energy Information Center, Haddam Neck, CT 06438
Denison Pequotsepos Nature Center, Mystic, CT 06355
Dinosaur State Park, West Street, Rocky Hill, CT 06067
James L. Goodwin Forest Conservation Center, Potter Road and Route 6, Hampton, CT 06247
Lutz Junior Museum, 126 Cedar Street, Manchester, CT 06040
Museum of Art, Science and Industry and Planetarium, 4450 Park Avenue, Bridgeport, CT 06604

Appendix K (continued)

Mystic Marinelife Aquarium, Coogan Boulevard, Mystic, CT 06355

The Nature Center for Environmental Activities, Inc., 10 Woodside Lane, Westport, CT 06880

Naval Submarine Base, New London, Groton, CT 06340

New Britain Youth Museum, 30 High Street, New Britain, CT 06050

Norma Terris Humane Education and Nature Center, Salem Road, East Haddam, CT 06423

Old MacDonald's Farm, Exit 13 off New England Thruway, Norwalk, CT 06856

Peabody Museum, Yale University, 170 Whitney Ave., New Haven, CT 06520

Elliot Pratt Education Center, Inc., Papermill Road, R.R. 1, New Milford, CT 06776

Project Oceanology, Avery Point, Groton, CT 06340

Roaring Brook Nature Center, 70 Gracy Road, Canton, CT 06010

Solar heating, wind generator, computer controlled heating, Southern New England Telephone Co., New Haven, CT 06506

The Stamford Museum and Nature Center, 39 Scofieldtown Road, Stamford, CT 06903

Stevenson Hydroelectric Station in Monroe, Northeast Utilities, P.O. Box 1337, Stamford, CT 06094

Talcott Mountain Science Center, Montevideo Road, Avon CT 06001

The Tale of the Whale Museum, 3 Whale Oil Row, Huntington Street, New London, CT 06320

The Thames Science Center, Gallows Lane, New London, CT 06320

West Rock Nature Recreation Center, Box 2969, New Haven, CT 06515

Willington Wild Animal Farm, Old Farms Road, Willington, CT 06279

Appendix L
Field Trip Authorization

Westport (CT) Schools

Instructions: Teacher to complete this form and send the entire three-part unit to principal for approval. If review by assistant superintendent or approval of superintendent is required, principal sends entire three-part unit for these approvals. Superintendent or assistant superintendent should keep last copy and return others to principal who will have teacher complete Part C.

Teacher ______________________ Grade/Subject _____ Date(s) ______
School ______________________ Number of Students* ________ Number of Adults* ______
*Legal capacity of bus is 65 occupants.
Destination ______________________ Type of trip (check one) __I __II __III
Date and Departure Time from (town) ____________ Date and Departure Time from Destination __________ Date and Arrival Time In (town) _________

Transportation (check one)	Costs		Sources	
_____ Bus	Transportation	$_______	Cost paid by each child	$_______
_____ Train	Admission Fees	$_______	Cost paid by other sources (specify)	$_______
_____ Car	Other	$_______	Total pupil cost of trip	$_______

Purpose of the trip: ____

____

I have reviewed the field trip policy and procedures. I will brief students and chaperones in accordance with that policy.

____
(Teacher's Signature)

Appendix L (continued)

APPROVALS

1. I hereby authorize the above Field Trip.

_______________________________ __________

(Signature of Principal) (Date)

Comments: _______________________________

2. I hereby authorize the above Field Trip.

_______________________________ __________

(Superintendent or Ass't. Sup't. whichever is applicable) (Date)

COMPLETION/FINAL ARRANGEMENTS

1. Prior to departure teacher should complete data below, keep second copy and return remainder to principal.

FINAL ARRANGEMENTS	YES	NO
1. Permission slips for all students received?	___	___
2. Names of students going on trip submitted to office?	___	___
3. Provisions made for students not going on trip?	___	___
4. Lunchroom notified?	___	___
5. Transportation arrangements confirmed?	___	___
6. Detailed itinerary sent to parents and principal for Type II and III trips?	___	___
7. Names and telephone numbers of parents to be notified in case of accident, emergency or change of plans obtained and filed with principal?	___	___

Appendix M
Planetariums in Connecticut

Bridgeport	Henry B. Dupont III Planetarium, 4450 Park Ave., Bridgeport, 06604 Leslie E. Birkmaier 203 372-3521 Est. 1962, 10 M. Dome, 125 seats, projector type G M−1
Bridgeport	University of Bridgeport Planetarium 285 Park Ave., Bridgeport, 06602 Est. 1971, projector type V Apollo
Danbury	Western Connecticut State College Planetarium, 181 White St., Danbury, 06810 Phillip K Lu 203 792-1400 Est. 1960, 8 M Dome, 48 seats, projector type S A2
East Lyme	East Lyme HS Planetarium, Chesterfield Rd., East Lyme, 06333 Donald M. Bloom, 203 739-6946 Est. 1972, 7 M Dome, 49 seats, projector type S A3P
Enfield	Enrico Fermi HS Planetarium, N. Maple St., Enfield, 06082 James Yankee, 203 749-2262 Est. 1971, 9 M Dome, 74 seats, projector type S A4
Glenville	Glenville Elementary School Planetarium, 33 Riverside Rd., Glenville, 06830 Charles E. Scovil, 203 531-9287 Est. 1974, 5 M Dome, 25 seats, projector type S 373
Hartford	Hartford Public HS Planetarium, 55 Forest St., Hartford, 06105 Charles W. Walker, 203 278-5920 Est. 1963, 7 M Dome, 60 seats, projector type S A3PR
Meriden	Meriden Science Trailer Planetarium, John Barry School, Meriden, 06450 Donald W. Fritz 3 M Dome, 20 seats, projector type S Nova
Milford	Joseph A. Foran HS Planetarium, Joseph A Foran HS, Milford, 06460 Allan Sacharow, 203 878-5771, Richard Hanley 877-0728, Reuben Ericson, 874-1463 Est. 1973, 9 M Dome, 70 seats, projector type VG MKIIA

Appendix M (continued)

Mystic
Seaport Planetarium, Mystic Seaport Inc., Mystic, 06355
Donald Treworgy, 203 536-2631
Est. 1960, 9 M Dome, 100 seats, projector type S A2

New Britain
Copernicus Hall Planetarium, 1615 Stanley St., New Britain, 06050
Frederick R. West, 203 827-7228
Est. 1974, 11 M Dome, 115 seats, projector type S 512

New Canaan
New Canaan HS Planetarium, New Canaan, 06840
Rachel P. Fitch, 203 966-9427
Est. 1971, 9 M Dome, 60 seats, projector type S A4

New Haven
Southern Conn. State College Planetarium, 501 Crescent St., New Haven, 06515
Donald E. Ehlers, 203 397-4293
Est. 1958, 7 M Dome, 80 seats, projector type S A1

New Milford
New Milford HS Planetarium, Sunny Valley Rd., New Milford, 06776
Thomas Danile
Est. 1970, 5 M Dome, 25 seats, projector type V EROS

Norwalk
R B Oliver Planetarium, Roton Middle School, Norwalk, 06854
Russell Harding, 203 847-0481
Est. 1967, 7 M Dome, 60 seats, projector type S A3PR

Stamford
Edgerton Memorial Planetarium, 39 Scofieldtown Rd., Stamford, 06903
Davis Mitchell, 203 322-1645
Est. 1957, 8 M Dome, 50 seats, projector type S A1

Storrs
University of Connecticut Planetarium, Physics Dept., Storrs, 06268
C. W. Peterson, 203 486-4915
Est. 1956, 5 M Dome, 25 seats, projector type S A2

Trumbull
Hillcrest Planetarium, Hillcrest Jr. H.S., Trumbull, 06611
Louis A. Prosek, 203 261-6411
Est. 1967, 10 M Dome, 80 seats, projector type S A3P

Wallingford
Mahan Planetarium, Sheehan HS, Wallingford, 06492
James J. Hellman, 203 265-2071
9 M Dome, 63 seats, projector type S A4

Washington
Shepaug Valley Middle HS P Shepaug Valley Middle HS, Washington, 06793
Bonnie L. Wooding, 203 868-7326
Est. 1972-76, 6 M Dome, 30 seats, projector type Nova III

West Hartford
Gengras Planetarium, 950 Troutbrook Dr., West Hartford, 06119
Robert Craig Robinson, 203 236-2961
Est. 1968, 12 M Dome 149 seats, projector type S SIP

Willimantic
Robert K. Wickware Planetarium, Eastern Connecticut State College, Willimantic, 06226
Mary C. Rogers, 203 456-2231
Est. 1972, 9 M Dome, 60 seats, projector type S A4

Windsor
Chapin Planetarium, Loomis School, Windsor, 06095
Est. 1959, 6 M Dome, 50 seats, projector type S A3P

Appendix N
State and National Events for Science Students

Connecticut Science Fair, Connecticut Science Fair Association, Inc., P.O. Box 14585, Hartford, CT 06114.

The State Science Fair is open to Connecticut students in grades 7–12 and is held in the spring of the year. A major benefit is the opportunity for the approximately 50 junior division (grades 7–12) and the senior division (grades 10–12) finalists in the several award disciplines to discuss their work with interested and knowledgeable scientists from industry and the academic community as a part of the final judging process.

Frontiers of Applied Science, Department of Engineering and Applied Science, Yale University, New Haven, CT, Werner Wolf, Chairman.

This event is held in the spring of the year. Applications go to high schools. 200 students (juniors) are selected on the basis of a short essay.

Junior Science and Humanities Symposium, Wesleyan University, Middletown, CT, Dr. Robert Rosenbaum, Director.

This event takes place in the spring of the year. It is open to about 150 students and 50 teachers. Lectures, demonstrations, and discussions with prominent scientists are featured.

National Youth Science Camp, West Virginia, Dr. Sigmund Abeles, State Department of Education, P.O. Box 2219, Hartford, CT 06115.

Application forms are sent to all public and private high schools. Two high achieving twelfth grade students are selected by a committee of the Connecticut Science Teachers Association. The winners represent Connecticut at a four-week summer science camp in West Virginia. They, along with representatives from the other forty-nine states, meet with scientists, U.S. Senators, Congressmen and other government officials; visit science facilities and engage in other camp activities. All travel, lodging and meal expenses are paid for by the State of West Virginia.

Westinghouse Science Talent Search, Science Service, 1719 N. Street, NW, Washington, DC 20036.

Applications go to high schools. High school seniors with high research ability in science and engineering are encouraged to apply. Three hundred students from across the nation are selected for the honors group. All members of this group are recommended for admis-

Appendix N (continued)

sion and scholarship awards to colleges and universities in the nation. Forty members from the honors group are designated top winners. This group of students is invited to Washington, DC, for a five-day institute usually held in late February. During this period they are judged for scholarships and awards in various dollar amounts.

Appendix O
Aids to Evaluation

Some resources which may be of help in developing and evaluating local science programs are:

ACES-NSTA High School Chemistry Tests. Division of Chemical Education, American Chemical Society, Examination Committee, University of Southern Florida, Tampa, FL 33620.

Basic Measurements and Evaluation of Science Instruction. Rodney L. Doran, National Science Teachers Association, 1742 Connecticut Avenue, NW, Washington, DC 20009.

Connecticut Science Assessment. Connecticut State Board of Education, Dr. Sigmund Abeles, Science Consultant, P.O. Box 2219, Hartford, CT 06115.

Guidelines for Self-Assessment of Secondary School Science Programs. National Science Teachers Association, 1742 Connecticut Avenue, NW, Washington, DC 20009.

Making the Classroom Test: A Guide for Teachers. Educational Testing Service, Princeton, NJ 08541.

Mental Measurement Yearbook. Oscar K. Buros, Gryphon Press, Highland Park, NJ 08904.

Resource Book of Test Items—Biological Science Curriculum Study, Yellow Version. Harcourt Brace Jovanovich, 757 Third Avenue, New York, NY 10017.

Resource Book of Test Items—Biological Science Curriculum Study, Green Version. Rand, McNally & Company, School Division, Box 76000, Chicago, IL 60680.

Standardized Science Tests: a descriptive listing of elementary & secondary. National Science Teachers Association, 742 Connecticut Avenue, NW, Washington, DC 20009.

STEP Science—Physics. Addison-Wesley Testing Services, Reading, MA 01867.

Testing, Teaching and Learning. Ralph W. Tyler and Sheldon H. White, National Institute of Education, U.S. Department of Education, Washington, DC 20208.

Unpublished Evaluation Instruments in Science Education: A Handbook. Victor J. Mayer, ERIC/SMEAC Science, Mathematics and Environmental Education Clearinghouse, Ohio State University, Columbus, OH 43212.

Science Teaching and Testing. Leo Nedelsky, Harcourt, Brace and World, NY 10017.

In addition, most publishers provide testing programs which are correlated with their textbooks.

Appendix P
Additional Resources

Books

Abruscato, J. and J. Hassard. *The Whole Cosmos Catalog of Science Activities*. Santa Monica, CA: Goodyear Publishing Co., 1977.

Anderson, R.O., et al. *Developing Children's Thinking Through Science*. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1970.

Beck, W.S. *Modern Science and the Nature of Life*. Garden City, NY: Natural History Press, 1961.

Beveridge, W.I.B. *The Art of Scientific Investigation*. New York: Vintage Books, 1957.

Brandwein, P., F. Watson and P. Blackwood. *Teaching High School Science: A Book of Methods*. New York: Harcourt, Brace and World, 1958.

Bronowski, J. *Science and Human Values*. New York: Harper Torchbooks, 1960.

Butterfield, H. *The Origins of Modern Science*. New York: Collier Books, 1957.

Coble, C., P. Hounshell and A. Adams. *Mainstreaming Science and Mathematics: Special Ideas and Activities for the Whole Class*. Santa Monica, CA: Goodyear Publishing Co., 1977.

Conant, J.B. *Science and Common Sense*. New Haven: Yale University Press, 1961.

DeVito, A. and G. Krockover. *Creative Sciencing: A Practical Approach*. Boston: Little, Brown & Co., 1980.

DeVito, A. and G. Krockover. *Creative Sciencing: Ideas and Activities for Teachers and Children*. Boston: Little, Brown & Co., 1980.

Farmer, W. and M. Farrell. *Systematic Instruction in Science for the Middle and High School Years*. Reading, MA: Addison-Wesley Publishing Co., Inc., 1980.

Goldstein, P. *How To Do An Experiment*. New York: Harcourt, Brace and World, 1957.

Hansell, M. and J. Aitken. *Experimental Animal Behavior: A Selection of Laboratory Exercises*. London: Blackie and Son, Ltd., 1977.

Harbeck, M., editor. *2nd Sourcebook for Science Supervisors*. Washington, DC: National Science Teachers Association, 1976.

Harding, D., R. Volker and D. Fagle. *Creative Biology Teaching*. Ames, IA: The Iowa State University Press, 1969.

Harlan, J. *Science Experiences for the Early Childhood Years*. Columbus, OH: Charles E. Merrill Publishing Co., 1980.

Heller, R., editor. *Geology and Earth Science Sourcebook for Elementary and Secondary Schools*. 2nd edition. New York: Holt, Rinehart & Winston, 1970.

Hone, E., A. Joseph and E. Victor. *Teaching Elementary Science: A Sourcebook for Elementary Science*. New York: Harcourt Brace Jovanovich, Inc., 1971.

Hounshell, P. and I. Trollinger. *Games for the Science Classroom: An Annotated Bibliography*. Washington, DC: National Science Teachers Association, 1977.

Ivany, J. *Today's Science: A Professional Approach to Teaching Elementary School Science*. Chicago: Science Research Associates, 1975.

Jenkins, E. *American Black Scientists and Inventors*. Washington, DC: National Science Teachers Association, 1975.

Joseph, A., et al. *Teaching High School Science: A Sourcebook for the Physical Science*. New York: Harcourt, Brace and World, 1961.

Kahle, J. *Teaching Science in the Secondary School*. New York: Van Nostrand Reinhold Co., 1979.

Kuslan, L. and A. Stone. *Teaching Children Science: An Inquiry Approach*. 2nd edition. Belmont, CA: Wadsworth Publishing Co., 1972.

Laun, H. *The Natural History Guide*. Alton, IL: Alsace Books and Films, 1967.

Mandell, A. *The Language of Science*. Washington, DC: National Science Teachers Association, 1974.

Mayer, W., editor. *Biology Teacher's Handbook*. 3rd edition. New York: John Wiley & Sons, Inc., 1978.

McGavack, J. and D. LaSalle. *Crystals, Insects, and Unknown Objects: A Creative Approach to the Teaching of Science to Intermediate School Children*. New York: John Day Co., Inc., 1971.

McGavack, J. and D. LaSalle. *Guppies, Bubbles and Vibrating Objects; A Creative Approach to the Teaching of Science to Very Young Children*. New York: John Day Co., Inc., 1969.

Morholt, E., et al. *Teaching High School Science: A Sourcebook for the Biological Sciences*. 2nd edition. New York: Harcourt, Brace and World, 1966.

National Science Teachers Association. *Ideas for Teaching Science in the Junior High School*. Washington, DC: 1963.

National Science Teachers Association. *How to. . .Series*. Washington, DC. (A set of helpful pamphlets on many topics of interest to science teachers. New pamphlets are added from time to time.)

Orlans, B. *Animal Care From Protozoa to Small Mammals*. Reading, MA: Addison-Wesley Publishing Co., Inc., 1977.

Palmer, L. (revised by H.S. Fowler). *Fieldbook of Natural History*. 2nd edition. New York: McGraw-Hill Book Co., 1975.

Reichenbach, H. *The Rise of Scientific Philosophy*. Berkeley: University of California Press, 1962.

Romey, W. *Inquiry Techniques for Teaching Science*. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1968.

Rowe, M.B. *Teaching Science as Continuous Inquiry*. 2nd edition. New York: McGraw-Hill Book Co., 1978.

Appendix P (continued)

Schwab, J. and P. Brandwein. *The Teaching of Science*. Cambridge: Harvard University Press, 1962.

Science Teaching Center. *Guidebook to Constructing Inexpensive Science Teaching Equipment*. (Volume 1: Biology, Volume 2: Chemistry, and Volume 3: Physics). College Park, MD: Science Teaching Center, 1972.

Trojcak, D. *Science with Children*. New York: McGraw-Hill Book Co., 1979.

United Nations Educational Scientific and Cultural Organization (UNESCO). *New UNESCO Sourcebook for Science Teaching*. New York: Unipub, 1973.

Journals

American Biology Teacher. National Association of Biology Teachers, 11250 Roger Bacon Drive, Reston, VA 22090.

Connecticut Journal of Science Education. Connecticut Science Teachers Association, Wallingford, CT 06492.

Educator's Guide to Free Science Materials (published annually). Educator's Progress Service, Randolph, WI 53956.

Journal of Chemical Education. Circulation Service, 119 W. 24th Street, 4th Floor, New York, NY 10011.

Journal of Environmental Education. Heldref Publications, 4000 Albemarle Street, NW, Washington, DC 20016.

Journal of Geological Education. National Association of Geology Teachers, P.O. Box 368 Lawrence, KS 66044.

Journal of Research in Science Teaching. National Association for Research in Science Teaching, John Wiley & Sons, Inc., 605 Third Avenue, New York, NY 10016.

Natural History. American Museum of Natural History, Central Park West at 79th Street, New York, NY 10024.

The Physics Teacher. American Association of Physics Teacher, Graduate Physics Building, State University of New York, Stony Brook, NY 11794.

Science. American Association for the Advancement of Science, 1515 Massachusetts Avenue, NW, Washington, DC 20005.

Science and Children. National Science Teachers Association, 1742 Connecticut Avenue, NW, Washington, DC 20009.

Scientific American. Subscription Department, 415 Madison Avenue, New York, NY 10017.

Sky and Telescope. Sky Publishing Corporation, Harvard University Observatory, Cambridge, MA 02138.

The Science Teacher. National Science Teachers Association, 1742 Connecticut Avenue, NW, Washington, DC 20009.

Appendix Q
Regional Educational Service Centers

Area Cooperative Education Services (ACES)
800 Dixwell Avenue
New Haven, CT 06511

Capitol Regional Education Council (CREC)
212 King Philip Drive
West Hartford, CT 06117

Cooperative Educational Services (CES)
11 Allen Road
Norwalk, CT 06852

Eastern Connecticut Regional Educational Service Center (EASTCONN)
R. R. 2
Willimantic, CT 06226

Long-Range Educational Assistance for Regional Needs (LEARN)
P. O. Box 220
East Lyme, CT 06333

Regional Educational Services Concept through United Effort (RESCUE)
R. R. 2, Goshen Road
Litchfield, CT 06759

Appendix R
Connecticut Policy on Academic Freedom and Public Education

Academic freedom is the freedom to teach and to learn. In defending the freedom to teach and to learn, we affirm the democratic process itself. American public education is the source of much that is essential to our democratic heritage. No other single institution has so significantly sustained our national diversity, nor helped voice our shared hopes for an open and tolerant society. Academic freedom is among the strengths of American public education. Attempts to deny the freedom to teach and to learn are, therefore, incompatible with the goals of excellence and equity in the life of our public schools.

With freedom comes responsibility. With rights come obligations. Accordingly, academic freedom in our public schools is subject to certain limitations. Therefore, the STATE BOARD OF EDUCATION affirms that:

Academic freedom in our public schools is properly defined within the context of law and the constraints of mutual respect among individuals. Public schools represent a public trust. They exist to prepare our children to become partners in a society of self-governing citizens. Therefore, access to ideas and opportunities to consider the broad range of questions and experiences which constitute the proper preparation for a life of responsible citizenship must not be defined by the interests of any single viewpoint. Teachers, school administrators, librarians, and school media specialists must be free to select instructional and research materials appropriate to the maturity level of their students. This freedom is itself subject to the reasonable restrictions mandated by law to school officials and administrators. At the same time, local school officials must demonstrate substantial or legitimate public interest in order to justify censorship or other proposed restrictions upon teaching and learning. Similarly, local boards of education cannot establish criteria for the selection of library books based solely on the personal, social or political beliefs of school board members. While students must be free to voice their opinions in the context of a free inquiry after truth and respect for their fellow students and school personnel, student expression which threatens to interfere substantially with the school's function is not warranted by academic freedom. Students must be mindful that their rights are neither absolute nor unlimited. Part of responsible citizenship is coming to accept the consequences of the freedoms to which one is entitled by law and tradition. Similarly, parents have the right to affect their own children's education, but this right must be balanced against the right other parents' children have to a suitable range of educational experiences. Throughout, the tenets of academic freedom seek to encourage a spirit of reasoned community participation in the life and practices of our public schools.

Since teaching and learning are among the missions of our public schools, the STATE BOARD OF EDUCATION affirms the distinction between teaching and indoctrination. Schools should teach students how to think, not what to think. To study an idea is not necessarily to endorse an idea. Public school classrooms are forums for inquiry, not arenas for the promulgation of particular viewpoints. While communities have the right to exercise supervision over their own public school practices and programs, their participation in the educational life of their schools should respect the constitutional and intellectual rights guaranteed school personnel and students by American law and tradition.

Accordingly, the STATE BOARD OF EDUCATION, in order to encourage improved educational practices, recommends that local school boards adopt policies and procedures to receive, review, and take action upon requests that question public school practices and programs. Community members should be encouraged, and made aware of their rights to voice their opinions about school practices and programs in an appropriate administrative forum. The STATE BOARD OF EDUCATION further recommends that local school boards take steps to encourage informed community participation in the shared work of sustaining and improving our public schools.

Finally, the STATE BOARD OF EDUCATION affirms that community members and school personnel should acknowledge together that the purpose of public education is the pursuit of knowledge and the preparation of our children for responsible citizenship in a society that respects differences and shared freedom.

Adopted by State Board of Education
September 9, 1981

Connecticut State
Department of Education

Division of Elementary and Secondary Education

Robert Margolin, Associate Commissioner
and Division Director

Francis McElaney, Assistant Division Director

Bureau of Curriculum and Staff Development

Betty Sternberg, Bureau Chief

Sigmund Abeles, Consultant in Science

Velma Adams, Editor